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MANUAL

OF THE

AMERICAN RAILWAY ENGINEERING ASSOCIATION

THE OBJECT OF THIS ASSOCIATION IS THE ADVANCEMENT OF KNOWLEDGE
PERTAINING TO THE SCIENTIFIC AND ECONOMIC LOCATION,
CONSTRUCTION, OPERATION AND MAINTENANCE OF
RAILWAYS. ITS ACTION IS NOT BINDING UPON
ITS MEMBERS.

EDITION OF 1911

PUBLISHED BY

AMERICAN RAILWAY ENGINEERING ASSOCIATION

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PREFACE.

"Tempora mutantur et nos mutamur in illis."

In the publication of this volume the Board of Direction of the Association feels that while there is yet room for improvement, it indicates a decided step forward in the advancement of the science of Railway Engineering and Maintenance of Way. The definitions, specifications, and principles of practice herein contained are the result of arduous labor by standing and special committees appointed to consider each subject and careful consideration by the annual conventions which have been held since the organization of the Association.

The reason for the existence of the Association and its methods of working are aptly expressed in the following extracts from the remarks of Mr. John F. Wallace in his inaugural address as the President of the Association at its first annual convention in Chicago in March, 1900:

"It is unnecessary for me to say that this Association fills a long-felt want, and that it has a broad field to develop. If the work is industriously and systematically carried forward, it will gradually assist us all in attaining the end sought for.

"It has been the custom of engineering and maintenance of way associations heretofore to carry on their work without that system and continuity of purpose which is the only true means of successfully accomplishing the desired results. The work of our Association has been laid out on unique lines. It is the intention to cover the entire field of engineering and maintenance of way research, divide up the subjects in systematic order, and continue and increase our standing committees and the subjects under consideration from time to time in order to do so.

"The first work of each Committee should be the collection of facts, which should be properly compiled, condensed and abstracted for the information of the Association at large. As the facts are obtained under the different heads or subheads, reports can, of course, be made from time to time by the different Committees on those subjects which have been considered.

"The Committees should not overlook the necessity and importance of working as a unit and fully comparing and discussing results in committee meetings. When they come before this Association as a body they should come as a unit and act together, and it is expected that they will be prepared to answer all questions that may be asked by members of the Association in regular meetings, and explain or defend the positions taken by the Committee.

"We should not forget that we are the servants of the investors in railway securities and that it is our duty to endeavor to secure the largest possible return on the capital invested. It is the function of the railway to furnish transportation to the public with the maximum amount of speed and safety to persons and property, the greatest convenience to its patrons, and at a minimum cost. We should have it in mind that the highest economy in the location, construction, maintenance and operation can only be obtained when the interest on cost of construction, plus the expense of maintenance and operation, are kept down to the minimum.

"The ultimate result of all railroad expenditures is, and should be, net profit to the investor.

"While the question of what is economical management respecting maintenance of way and structures is one which the management of each property must solve for itself, we can certainly assist each other by a full and frank comparison of views and a discussion of the various elements that constitute an economical handling of our maintenance of way work. *The establishment of certain recognized principles as the result of our investigations and discussions will materially assist our managements in adopting a policy that will lead to the truest and highest economy.*"

It is intended that this volume shall contain results only, but with each subject reference is given to the volume of the Proceedings containing the full Committee reports and discussions thereon. The first edition of the Manual was published in 1905. The second edition was published in 1907. Supplements containing changes and additions were published in Bulletin No. 79, September, 1906, and Bulletin No. 103, September, 1908.

In the present edition the entire work of the Association has been brought up to date, each Committee reviewing its own subject matter.

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SPECIAL COMMITTEE.

CLASSIFICATION OF RAILWAYS.

Class "A" includes all districts of a railway having more than one main track, or those districts of a railway having a single main track with a traffic that equals or exceeds the following:

Freight car mileage passing over district per year per mile, 150,000; or, Passenger car mileage per year per mile of district, 10,000; with maximum speed of passenger trains of 50 miles per hour.

Class "B" includes all districts of a railway having a single main track with a traffic that is less than the minimum prescribed for Class "A," and that equals or exceeds the following:

Freight car mileage passing over district per year per mile, 50,000; or Passenger car mileage per year per mile of district, 5,000; with maximum speed of passenger trains of 40 miles per hour.

Class "C" includes all districts of a railway not meeting the traffic requirements of Classes "A" or "B."

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* Vol. 7, 1906, pp. 331, 340; adopted by letter ballot, June, 1906; Vol. 8, 1907, p. 15.

COMMITTEE I.

ROADWAY.

*DEFINITIONS.

Group A—General.

Classification.—Arranging the material into groups according to its character.

Contract.—A written agreement between two or more parties specifying terms, conditions, etc., under which certain obligations must be performed. (Specifications are a part of the contract.)

Estimate (noun).—(a) A statement of work performed or material furnished, according to which payment is to be rendered.

Estimate (noun).—(b) A statement showing the probable cost of a proposed piece of work.

Estimate (verb).—The act of making an estimate.

Quantities.—The amount of material to be handled, expressed in the usual units.

Slide.—The movement of a part of the earth under the force of gravity.

Specification.—That part of the contract describing the details of construction.

Unit Price.—The price per unit of the various quantities specified in a contract for which a certain work is to be performed.

Washout.—The carrying off of the permanent way by the impact and erosion of flood waters.

Group B—Right-of-Way.

Right-of-Way.—The land or water rights necessary for the roadbed and its accessories.

Roadbed.—The finished surface of the roadway upon which the track and ballast rest.

Roadway.—That part of the right-of-way of a railway prepared to receive the track.

Station Grounds.—Property to be used for station purposes.

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*Adopted, Vol. 7, 1906, pp. 341-343, 442, 443; Vol. 11, Part 2, 1910, pp. 1063, 1087.

Group C—Technical.

Alinement.—The horizontal location of a railway with reference to curves and tangents.

Center Line.—A line indicating the center of an excavation, embankment or track.

Contour.—The line of intersection between a horizontal plane and a given surface.

Cross-Section.—A section through a body perpendicular to its axis.

Center Stakes.—Stakes indicating the center line.

Elevation or Height.—The distance of any given point above or below an established plane or datum.

Finishing Stakes.—Final stakes set for the completion of the work.

Grade (verb).—To prepare the ground for the reception of the ballast and track.

Grade-Line.—The line on the profile representing the tops of embankments and bottoms of cuttings ready to receive the ballast.

Gradient.—The rate of inclination of the grade-line from the horizontal.

Plan.—A drawing furnished for guidance of work.

Profile.—The intersection of a longitudinal vertical plane with the ground or established gradients; or a drawing representing the same.

Slope.—The inclined face of a cutting or embankment.

Slope Stakes.—Stakes set to indicate the top or bottom of a slope.

Subgrade.—The tops of embankments and bottoms of cuttings ready to receive the ballast.

Top of Slope.—The intersection of a slope with the ground surface in cuts, and the plane of roadbed on embankment.

Toe of Slope.—The intersection of a slope with the ground surface in embankments, and the plane of roadbed in cuts.

Group D—Clearing.

Clearing.—Removing natural and artificial obstructions to grading.

Grubbing.—Removing the stumps and roots.

Brush.—Small trees, shrubs or branches of trees that have been cut off.

Group E—Drainage.

Bog.—Soft, spongy ground, usually wet and composed of more or less vegetable matter.

Channel.—The depression or cut in which a stream is confined.

Culvert.—An arched, circular or flat covered drain of timber, iron, brick or masonry, carried under the roadbed for the passage of water.

Drain.—An artificial waterway for conducting water from the roadway.

Drainage.—The interception and removal of water from, upon or under the roadway.

Ditch.—An open artificial waterway for providing drainage.

Intercepting Ditch.—An open artificial waterway for preventing surface water from flowing over the slopes of a cut or against the foot of an embankment.

Subdrain.—A covered drain, below the roadbed or ground surface, receiving the water along its length by absorption or through the joints.

Trench.—A narrow, shallow excavation to receive a structure.

Waterway.—A channel, either natural or artificial, for conducting the flow of water.

Group F—Grading.

Average Haul.—The mean distance material is to be hauled.

Average Total Haul.—The average total distance material is to be hauled.

Benched.—Formed into a series of benches.

Berme.—(a) The space left between the top or toe of slope and excavation made for intercepting ditches or borrow pits.

Berme.—(b) An approximately horizontal space introduced in a slope.

Borrow (verb).—To take material from a borrow pit.

Borrow (noun).—Material removed from a borrow pit.

Borrow Pit.—An excavation made for the purpose of obtaining material.

Embankment (or Fill).—A bank of earth, rock or other material constructed above the natural ground surface.

Excavation (or Cutting).—(a) The cutting down of the natural ground surface; (b) The material taken from cuttings, borrow pits or foundation pits; (c) The space formed by removing material.

Foundation Pit.—The excavation in which the foundation of a structure is laid.

Haul (or Free Haul).—The distance within a given limit that material is hauled in constructing the roadbed.

Overhaul.—The distance beyond a given limit that material is hauled in constructing the roadbed.

Shrinkage.—The contraction of material.

Stepped.—Formed into a series of steps.

Tamped (or Packed).—Packed down by light blows.

Total Haul.—The total distance that material is to be hauled.

WASTE—Material in excess of that required to make an embankment of given cross-section.

WASTE OR SPOIL BANKS.—Excavated material not required to form embankments.

Group G—Tunnels.

CURB.—A broad, flat ring of wood, iron or masonry, placed under the bottom of a shaft to prevent unequal settlement, or built into the walls at intervals for the same purpose.

ROCK.—A solid mass of mineral substance.

SHAFT.—A pit or well sunk from the ground surface above into a tunnel for the purpose of furnishing ventilation or for facilitating the work by increasing the number of points from which it may be carried on.

TUNNEL.—An excavated passageway under ground or water.

WELL (or Sump).—A cistern or well into which water may be conducted by ditches to drain other portions of a piece of work.

*GENERAL CONTRACT REQUIREMENTS.

(1) Similarity in the form of specifications.

(2) Measurement of clearing and grubbing should be made in units of one hundred (100) feet square.

(3) A three-fold classification of materials: Solid Rock, Loose Rock and Common Excavation, and in special cases such additional classification of material as may seem necessary, such additional classes to be distinctly defined and specified in the contract.

(4) Profiles should be made complete in regard to distribution of material.

(5) There should be recognized three widths of roadbed for standard gage railways, and these should be selected to suit the probable density of traffic. These widths should be 14, 16 and 20 feet.

(6) The width between center lines of main tracks should be thirteen (13) feet.

(7) Rock excavations should be taken out not less than six (6) in. below subgrade.

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*Adopted, Vol. 4, 1903, pp. 32, 35, 39, 44, 66, 74; Vol. 5, 1904, pp. 688, 719; Vol. 6, 1905, pp. 123, 136-138, 142, 144, 145, 164-173.

(8) No waste should be permitted closer than ten (10) ft. from the slope stakes.

(9) Information on profiles as to distribution of material should be so arranged that the price for grading for each of the classes may cover the haul, irrespective of distance.

*WIDTH OF ROADWAY AT SUBGRADE.

(1) Class A railways, with constant and heavy traffic, should have a minimum permanent width of twenty (20) ft. at subgrade.

(2) In the theory upon which the width of embankment at subgrade is based it is considered that the track, in excavations, is placed upon what is virtually a low embankment; and in order to preserve uniformity of conditions immediately under the track throughout the line, the width of subgrade in excavations should be made the same as on embankments, outside of which sufficient room should be allowed for side ditches.

†SLOPES OF ROADWAY CROSS-SECTION.

Local conditions and the character of material should invariably be taken into account in determining the permanent slopes of the roadway cross-section.

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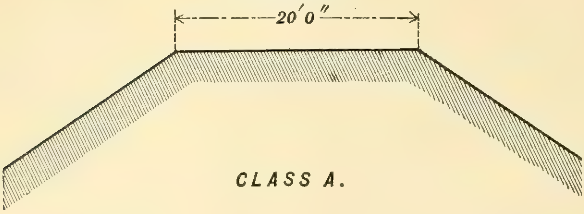
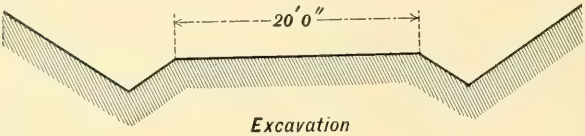
*Adopted, Vol. 3, 1902, pp. 34, 37, 43; Vol. 6, 1905, pp. 122, 123.
†Adopted, Vol. 3, 1902, pp. 34, 45; Vol. 6, 1905, pp. 122, 123.

STANDARD ROADWAY PLANS.

Embankment

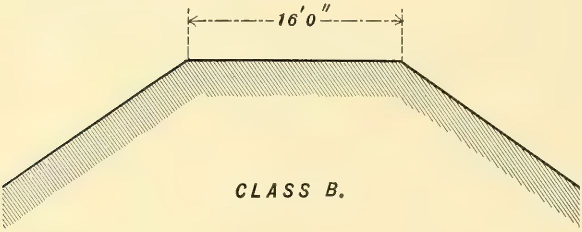


CLASS A.

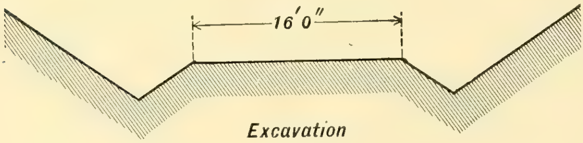


Excavation

Embankment

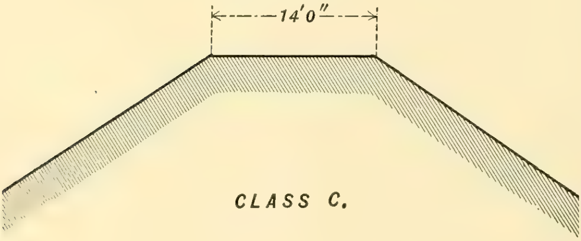


CLASS B.

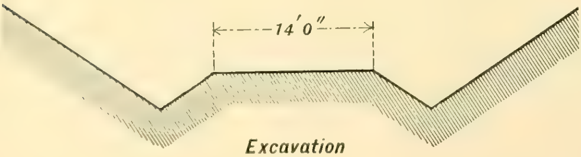


Excavation

Embankment



CLASS C.



Excavation

*SPECIFICATIONS FOR THE FORMATION OF THE ROADWAY.

GENERAL.

Alinement. 1. The center of the roadway shall conform in alinement to the center stakes.

Subgrade. 2. The grade-line on the profile denotes subgrade, and this term indicates the tops of embankments or the bottoms of excavations ready to receive the ballast.

Cross-section. 3. The roadway shall be formed to the section, slopes and dimensions shown upon the standard drawings, or as may be directed from time to time.

Width of Roadway. 4. When finished and properly settled the roadway shall conform to the finishing stakes and shall be of the following dimensions at subgrade, for single track, viz.:

On embankments .... (....) ft. wide, and in excavations .... (....) ft., exclusive of the width necessary for ditches. For each additional track an additional width of .... (....) ft. shall be made.

Slopes. 5. The slopes of embankments and excavations shall be of the following inclinations, as expressed in the ratio of the horizontal distance to the vertical rise:

Embankments, Earth—One and one-half to one;
Rock—From one to one, to one and one-half to one;
Excavations, Earth—One and one-half to one;
Loose Rock—One-half to one;
Solid Rock—One-quarter to one.

These ratios may be varied according to circumstances, and the slopes shall be made as directed in each particular case.

CLEARING.

Extent of Clearing. 6. The right-of-way and station grounds, except any portions thereof that may be reserved, shall be cleared of all trees, brush and perishable materials of whatsoever nature.

Disposal of Brush, Etc. 7. All these materials, except as hereinafter mentioned, shall be burned or otherwise removed from the ground, as may be directed, and without injury to adjoining property.

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*Adopted, Vol. 4, 1903, pp. 20-29, 33-35, 78-109; Vol. 5, 1904, pp. 675-684, 688, 719; Vol. 6, 1905, pp. 125-136, 143-164; Vol. 11, Part 2, 1910, pp. 1062, 1063, 1064, 1087.

Stumps.

8. Where clearing is to be done, stumps shall be cut close to the ground, not higher than the stump top diameter for trees twelve (12) in. and less in diameter, and not higher than eighteen (18) in. for trees whose stump top diameter exceeds twelve (12) in., except between slope stakes of embankments, where stumps may be cut so that the depth of filling over them shall not be less than two and one-half (2½) ft.

Clearing in Advance.

9. The work of clearing shall be kept at least one thousand (1,000) ft. in advance of grading.

Cutting and Piling Wood.

10. All trees which may be reserved shall be stripped of their tops and branches, made into ties, or cut to such lengths as may be directed, and neatly piled at such places on the right-of-way as may be designated, for which service payment shall be made by the tie, or by the cord of one hundred and twenty-eight (128) cubic ft.

Isolated Trees, Buildings, Etc.

11. In localities where isolated trees and buildings exist, payment shall be made for their removal at a price to be agreed upon.

Measurement.

12. Measurement of clearing and payment for the same shall be by units of one hundred (100) ft. square, or fraction thereof, actually cleared.

GRUBBING.

Extent.

13. Stumps shall be grubbed entirely from all places where excavations occur, including ground from which material is to be borrowed as well as from ditches, new channels for waterways and other places where required.

Grubbing shall also be required between the slope stakes of all embankments of less than two and one-half (2½) ft. in height.

Grubbing in Advance.

14. The work of grubbing shall be kept at least three hundred (300) ft. in advance of grading.

Measurement.

15. Measurement of grubbing shall be estimated upon all excavation actually done, and the space to be covered by all embankments of less than two and one-half (2½) ft. in height. Payment for the same shall be by units of one hundred (100) ft. square, or fraction thereof, actually grubbed.

GRADING.

16. The term "Grading" in these specifications includes all excavations and embankments for the formation of the roadbed, ditching, diversions of roads and streams, foundation pits, and all similar works pertaining to the construction of the railway, its sidetracks and station grounds.

Work Included. Classification.

17. All material excavated shall be classified as "Solid Rock," "Loose Rock," "Common Excavation," or such additional classifications of material as may be established before the award of the contract.

18. Solid Rock shall comprise rock in solid beds or masses in its original position which may be best removed by blasting; and boulders or detached rock measuring one cubic yard or over. **Solid Rock.**

19. Loose Rock shall comprise all detached masses of rock or stone of more than one cubic foot and less than one cubic yard, and all other rock which can be properly removed by pick and bar and without blasting; although steam shovel or blasting may be resorted to on favorable occasions in order to facilitate the work. **Loose Rock.**

20. Common Excavation shall comprise all other materials of whatsoever nature that do not come under the classification of solid rock, loose rock, or such other classifications as may be established before the award of the contract. **Common Excavation.**

21. Slopes of all excavations shall be cut true and straight, and all loose stones in the slopes shall be removed. **Finishing Slopes.**

22. Rock excavation shall in all cases be taken out ....(....) in. below subgrade and refilled to subgrade with approved material. **Excavation Below Subgrade.**

23. Excavation in excess of the authorized cross-section, as well as slides extending beyond the slope lines, shall not be paid for unless such are due to causes which are not under the control of the contractor or his agents. In all cases the surplus material shall be removed by the contractor without delay and the slopes reformed. The classification of the material shall be in accordance with its condition at the time of removal, regardless of prior conditions. **Excess Excavation and Slips.**

24. Where the quantity of excavation exceeds that required to make the embankments to standard cross-section, the surplus shall be used to widen the embankments uniformly, along one or both sides, as may be directed, and no material shall be deposited in waste banks unless such waste be indicated either on the profiles or by written order. **Disposal of Excess Excavation.**

25. Where wasting is ordered the material shall, if possible, be deposited below grade-line, and under no circumstances shall the waste bank have its nearest edge within .... (....) ft. of the slope stakes of the cutting. **Waste Banks.**

26. Where the quantity of excavation from the cuttings of standard cross-section is insufficient to form the embankments, the deficiency shall be made up by widening the cuttings on one or both sides of the center line, as may be directed. No material shall be taken from borrow pits, unless such borrow be indicated either on the profiles or by written order. **Borrow Pits, Etc.**

Approximate Quantities Shown. 27. The classification and quantities shown on the profile exhibited for distribution of material are approximate only, and shall in no way govern the final estimate. The company reserves the right to increase or diminish the quantities given without affecting the contract unit prices for the various parts of the work.

Reserving Gravel, Etc. 28. Where gravel, stone or any other material suitable for special use of the company is met within the excavations, the same shall, when required, be reserved and deposited in convenient places on the right-of-way, as directed, and other suitable material in the vicinity substituted, as required, to complete the embankments.

Berme in Rock Cuttings. 29. A berme of .... (....) ft. shall be left between the top of slope of rock cuttings and toe of slope of the overlying earth.

Intercepting Ditches. 30. Intercepting ditches, when ordered, shall be made at the top of the slopes of all cuttings where the ground falls toward the top of the slopes, and they must diverge sufficiently to prevent erosion of the adjoining embankment. The cross-sections and locations of such ditches shall be designated and, if required, they shall be made in advance of opening the cutting.

Ditches in Cuttings. 31. Ditches shall be formed at the bottom of the slopes in cuttings according to the cross-sections shown upon the plans, or such modifications thereof as may be directed; they shall be neatly made, clear of obstructions, and at the lower ends must diverge sufficiently to prevent erosion of the adjoining embankments.

Subdrains. 32. Subdrains of tile shall be constructed of the size and location as directed. Trenches for these drains shall be taken out at least ....(....) in. below frost line; the tiles shall be laid on a bed which shall be true, with half round sections, with a filling of at least ....(....) in. of cinders or other suitable material on either side and above the tile, and then covered with ordinary soil to the top of the trench.

Measurement and payment for such drains shall be by the linear foot, according to the diameter of tile, including excavation and refilling; the contractor to furnish all material.

Unsuitable Material. 33. Excavations incident to the construction of the roadbed, ditches, channels and roadways shall be used in forming the embankments. Frozen or other unsuitable material shall not be permitted to enter into their composition.

Formation in Layers.

34. When directed, embankments shall be built in horizontal layers of .... (....) ft. in thickness; these layers to be of the full width of the embankment and built to the true slope, and not widened with loose material from the top. The most suitable material shall in all cases be reserved for finishing the surface; large stones shall not be permitted within a depth of at least .... (....) ft. below subgrade.

Shrinkage, Etc.

35. Embankments shall be carried to such height above subgrade and to such increased width as may be deemed a necessary provision for shrinkage, compression and washing. As the embankments become consolidated, their sides shall be carefully trimmed to the proper slopes, and they must be maintained to their proper height, dimensions and shape until the work is finally accepted.

Embankments on Slopes.

36. Where an embankment is to be placed on sloping ground the surface shall be deeply plowed or stepped; and, whenever directed, boggy or unsuitable material shall be excavated so that the embankment shall be on a firm foundation.

Embankments Across Swamps.

37. In crossing bogs or swamps of unsound bottom for light fills a special substructure of logs and brushwood may be required, the logs forming this foundation to be not less than six (6) in. in diameter at the small ends. If necessary, there shall be two or more layers crossing each other at right angles, the logs of each layer being placed close together, with broken joints, and covered closely with brush; the bottom layer shall be placed transversely to the roadway and project at least five (5) ft. beyond the slope stakes of the embankment.

Measurement of this substructure and payment for the same shall be by units of one hundred (100) ft. square, or fraction thereof, of area covered by each layer.

Filling Trestles.

38. In forming embankments from trestles, the material shall be thoroughly compacted between the trestle bents and around and under all parts of the structure, and in case of train filling by means of a temporary trestle the material shall be uniformly spread in the fill.

Embankments at Trestles.

39. Embankments abutting the ends of trestle bridges shall be brought forward upon the structure a distance of at least .... (....) ft., with an increased width of .... (....) ft. in order to form a full roadbed.

Finishing Subgrade.

40. The subgrade shall be compact and finished to a true plane, and no depression left that will hold water.

Embankments Over Masonry, Etc.

41. In embankments over or about masonry or other structures the material shall be deposited in thin layers and each layer carefully tamped.

Special care must be exercised that no excessive strain be placed upon these structures, and only the best material shall be permitted for the purpose of such filling. The contract price for excavation shall cover the cost of obtaining, distributing and packing the material behind, over and around all such structures.

BORROW PITS.

Land Provided.

42. Land for borrow pits or waste banks shall be provided by the railway company.

Drainage.

43. Borrow pits shall be connected with ditches and drained to the nearest water course, when required. Unless directed, material shall not be borrowed to a depth that will prevent proper drainage.

Slopes and Bermes.

44. Side slopes of borrow pits on the right-of-way shall be the same as used in the cross-section of the adjoining roadbed. A berme of not less than .... (....) ft. in width shall be left between slope stakes of the embankment and the edge of the borrow pit, and a berme of not less than .... (....) ft. between the outside slope of the borrow pit and the right-of-way line. Bermes shall consist of the original unbroken ground.

Cross-sectioning of Pits, Etc.

45. Borrow pits shall not be excavated before they have been staked out, and borrowing must be done in regular shape in order to admit of ready and accurate measurement. Borrowing or wasting of material will not be permitted on land set apart for station grounds or for other special purposes except by written directions.

PRICE AND MEASUREMENT OF GRADING.

Basis.

46. Grading shall be estimated and paid for by the cubic yard at the prices specified for the respective materials. Measurement shall be made in excavation only, except in cases hereinafter mentioned.

Work Included in Price.

47. The contract prices per cubic yard shall include the excavation of the material by any method whatsoever; the loading, transportation and the deposit of the same in the manner prescribed by these specifications, and in the places designated; the plowing or benching of slopes; as well as all other expense incident to the work of grading.

Haul.

48. Unless otherwise specified, it is distinctly understood that the contract price per cubic yard covers any haul found necessary, and that there shall be no allowance made for any so-termed overhaul.

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*ALTERNATE OPTIONAL OVERHAUL CLAUSE.

(*The following alternate optional overhaul clause is recommended to be substituted for clause No. 48 of the Specifications for the Formation of the Roadway in all cases where it is desired to allow overhaul:*)

48-a. No payment shall be made for hauling material when the length of haul does not exceed the limit of free haul, which shall be .... ft. **Haul.**

The limits of free haul shall be determined by fixing on the profile two points—one on each side of the neutral grade point—one in excavation and the other in embankment, such that the distance between them shall equal the specified free-haul limit and the included quantities of excavation and embankment balance. All haul on material beyond this free-haul limit shall be estimated and paid for on the basis of the following method of computation, viz.:

All material within this limit of free haul shall be eliminated from further consideration.

The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, less the limit of free haul as above described, shall be the length of overhaul; and the compensation to be rendered therefor shall be determined by multiplying the yardage in the remaining mass, as above described, by the length of the overhaul. Payment of the same shall be by units of one cubic yard hauled one hundred (100) ft.

Where material is obtained from borrow pits along the embankment and runways are constructed, the haul shall be determined by the distance the team necessarily travels. The overhaul on material thus hauled shall be determined by multiplying the yardage so hauled by one-half the round distance made by the team less the free-haul distance. The runways shall be established by the engineer.

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49. If it be impracticable to measure borrowed material in excavation, it may be measured in embankment, using the cross-section notes of the embankment, and making a just and reasonable allowance for change in bulk, so that the quantities shall equal the excavation quantities as nearly as possible. **Embankment Measurement.**

50. No classification or allowance shall be made for loose or solid rock in borrow pits unless specific written instructions are given **Borrow Classification.**

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* Vol. 7, 1906, pp. 444-446; adopted by letter-ballot, June, 1906; Vol. 8, 1907, pp. 297, 313.

to the contrary, it being the intent and meaning of these specifications that all borrowed material shall be classified and paid for as common excavation.

TUNNEL EXCAVATION.

Line, Grade and Cross-section.

51. Tunnels shall be excavated to the alinement, gradients and sections shown upon the plans, or to such modifications thereof as may be directed.

Bottom of Rock Tunnels.

52. In rock tunnels the material shall in all cases be taken out .... (....) in. below subgrade and refilled to subgrade with approved material.

Blasting.

53. Blasting shall be done with all possible care so as not to damage the roof and sides, and all insecure pieces of rock beyond the standard cross-section shall be removed by the contractor.

Excess Excavation.

54. Excavation in excess of the authorized cross-section shall not be paid for.

Price to Include.

55. The price paid for tunnel excavation shall embrace the cost of removal of all materials between the outer faces of the portals, and shall include the loosening, loading, transportation and placing of the material in embankment or waste banks, as directed; it shall also include whatever materials and labor are required for temporary props, supports and scaffolding for the safe prosecution of the work, as well as all expense of keeping the tunnel ventilated and free from water, oil or gas.

Niches or Recesses.

56. Niches or recesses for the protection and convenience of the railway employes shall be provided at designated intervals.

Shafts.

57. The location, number and dimensions of all shafts shall be determined, and the excavation price for them shall cover all materials contained within the specified cross-section between the surface of the ground and the connection of the shafts with the tunnel; said price shall also cover all material and labor for curbing and support of the sides of the shafts, as may be required, the cost of keeping the shafts free of water or oil, as well as the cost of all pumping and hoisting machinery.

Wells or Sumps.

58. Wells or sumps within the tunnel necessary for its permanent drainage shall be made as directed and paid for at the same rate per cubic yard as for tunnel excavation.

Right-of-Way for Roads.

59. The contractor shall make all arrangements and be at the sole expense for any right-of-way necessary over the top of the tunnel for such roads as he may require between the ends of the tunnel, and all grading necessary for the same shall be done at his expense.

60. The contract prices per cubic yard for tunnel and shaft excavation, respectively, cover any haul found necessary in placing the material where designated, and there shall be no allowance for any so-termed overhaul. **Haul.**

CLAUSES SPECIALLY APPLICABLE TO REVISION OF EXISTING LINE OR WIDENING FOR ADDITIONAL TRACK.

61. The contractor shall arrange his work so that there will be no interference or delay in any manner with the train service of the company, and he shall be responsible for any damage to the company's property caused by his acts or those of his employes. Whenever the work is liable to affect the movement or safety of trains, the method of doing such work shall first be submitted for approval, without which it shall not be commenced or prosecuted. If continuous detention occurs to the train service, the company reserves the right to complete the work at the expense of the contractor after giving him written notice. **Safety of and Delay to Train Service.**

62. Heavy blasting shall not be permitted close to the main tracks, nor shall the contractor be permitted to transport material along or between the company's tracks, except when properly authorized. Whenever the work as authorized affects the safety of the trains or tracks, the company shall take such precautions as it may deem advisable to ensure safety, and the cost thereof shall be charged to the contractor and deducted from his estimate. **Precautions for Safety of Trains and Tracks.**

63. The contractor shall not move the company's tracks or in any way interfere with them under any circumstances. Whenever it becomes necessary that the main line or side tracks be moved, it shall be done by the company, and the actual cost thereof charged to the contractor and deducted from his estimate. **When and How Company's Tracks May Be Moved.**

64. The location of the additional track shall be on the .... side of existing line, but whenever it is expedient to change any portion to the opposite side, the altered alinement shall be shown upon the maps or diagrams furnished by the company, and the contractor shall conform to the same without extra charge. **Location of Additional Track.**

65. Wherever the existing embankment of .... (....) ft. in height or over is raised or widened, the slope of the existing embankment shall be deeply plowed in order to bind the new material thoroughly to it. **Plowing Slopes.**

66. Wherever it is necessary for material of any description to be transported across the existing track or tracks, the location of the crossings must be approved. The material and labor of placing and main- **Crossings.**

taining the same shall be furnished by the company, and the actual cost charged to the contractor and deducted from his estimate.

Watchmen, Operators and Flagmen.

67. Watchmen, both day and night, shall be furnished by the company at the places it may consider necessary for the safety of the company's trains and works, and the cost shall be charged to the contractor and deducted from his estimate. It is distinctly understood, however, that the providing of such watchmen shall not relieve the contractor from the liability and payment for damages caused by his operations.

Safety Signals.

68. The cost of installment, maintenance and operation of all signals necessary to ensure the safety of trains, consequent upon the contractor's work, shall be borne by the contractor, and all instructions regarding their observance shall be strictly obeyed by him.

GENERAL CONDITIONS.

Temporary Fences.

69. Previous to or during the work of grading, the contractor, if directed, shall erect and maintain temporary fences in order to prevent trespass upon the railway or damage to adjoining property.

Crossings, Damage to Property, Etc.

70. The contractor shall, at his own expense, make and keep in good condition commodious passing places for public and private roads traversed by the line of railway; and he shall be held responsible for damages of whatsoever nature to persons or neighboring property caused by workmen in his employ leaving gates or fences open, blasting rocks, building fires or in other ways. If necessary, the payment of the estimate may be withheld until such damages are satisfactorily adjusted, the intention of the contract being that the company shall not be held responsible for any claims or losses incurred during the construction of the line, due to the operations or negligence of the contractor or his employes.

Changes of Alinement or Gradients, Etc.

71. The alinement, gradients and cross-sections of the roadbed, as well as ditches and other incidental work, may be altered in whole or in part as deemed necessary either before or after the commencement of the work; but any such change or alteration shall not affect the unit prices specified in the contract, nor shall any such changes or alterations constitute claims for damages, nor shall any claim be made or allowed on account of such changes or alterations.

Snow and Ice.

72. Before beginning the grading, as well as during the progress of the work, the contractor shall remove all snow and ice from between the slope stakes at his own expense.

Bench Marks and Stakes. 73. The contractor shall carefully preserve all bench marks and stakes, and in case of neglect to do so will be charged with the resulting expense.

Roads. 74. Wherever required, the contractor shall open up a safe road for passage on horseback and foot along the whole or any portions of the work under contract.

Temporary Roads, Trestles, Etc. 75. No allowance or compensation whatsoever shall be due or paid to the contractor for any temporary roads, bridges or trestles that he may make to facilitate the work.

Final Clearing Up. 76. Before the work is finally accepted the contractor shall at his own expense clear away from the company's property, as well as from public and private roads and the channels of streams and ditches, all rubbish and surplus blasted or excavated material.

Extra Work. 77. The cost of any extra work shall not be considered or allowed unless such extra work shall have been done by direction in writing, and such written directions shall in every case contain the rates and methods of payment for said extra work.

Contractor's Risk. 78. The contractor shall take all risks from casualties of every nature and shall not be entitled to any compensation for detentions from such causes. All stock, tools and machinery employed on the work by the contractor are at his risk while on the property of the railway company, and the contractor agrees to make no claim for injury or damage to same which may be caused by the operation of the railway.

Company Defined. 79. Wherever the word "Company" is used in these specifications it designates the .... Company.

Contractor Defined. 80. The word "Contractor" is used herein to designate the person or persons undertaking the work referred to in these specifications and drawings.

Work in Charge of. 81. In the foregoing specifications it is understood and agreed that the Chief Engineer of the .... Company is in charge of the work, and he may appoint such assistants as he may select. Wherever the specifications refer to the judgment, direction, decision, approval, etc., of an employe of the .... Company, they designate and mean the Chief Engineer or one of his assistants. The decision of the Chief Engineer shall be final as to the intent and meaning of these specifications.

Specifications Part of Contract. 82. The specifications and general conditions referred to are distinctly understood as being embodied with the contract, the whole forming the entire agreement between the Company and the Contractor.

*STEAM SHOVELS.

GENERAL REQUIREMENTS.

Three cardinal points should be given careful attention in the selection of a steam shovel for roadway construction. These are in their order:

(1) Care in the selection, inspection and acceptance of all material that enters into every part of the machine.

(2) Design for strength.

(3) Design for production.

GENERAL SPECIFICATIONS.

Weight of shovel: Seventy (70) tons.

Capacity of dipper: Two and one-half (2½) yards.

Steam pressure: One hundred and twenty (120) lbs.

Clear height above rail of shovel track at which dipper should unload: Sixteen (16) ft.

Depth below rail of shovel track at which dipper should dig: Four (4) ft.

Number of movements of dipper per minute from time of entering bank to entering bank: Three (3).

Character of hoist: Cable.

Character of swing: Cable.

Character of housing: Permanent for all employes.

Capacity of tank: Two thousand (2,000) gallons.

Capacity of coal bunker: Four (4) tons.

Spread of jack arm: Eighteen (18) ft. A special short arm should be provided.

Form of steam shovel track: "T" rails on ties.

Length of rails for ordinary work: Six (6) ft.

Form of rail joint: Strap.

REPAIR PARTS NECESSARY TO CARRY.

1 Hoisting cable,
1 Thrusting cable,
1 Swinging engine cable,
1 Set dipper teeth,
1 Dipper latch,
Duplicate of each sheave on machine.
12 Cold shunts,
6 Cable clamps,
1 U bolt,
Lot assorted bolts and nuts,
Lot assorted pipes and fittings,
Lot assorted waterglasses.

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*Adopted, Vol. 8, 1907, pp. 298-302, 343-346.

REPAIR TOOLS NECESSARY TO CARRY.

1 Blacksmith Forge with Anvil and complete tools,
1 Small Bench Vise,
3 Pipe Wrenches, assorted sizes,
3 Monkey Wrenches, assorted sizes,
6 Chilson Wrenches, assorted sizes,
1 Ratchet with assorted Twist Drills,
6 Round Files, assorted sizes,
1 Hack-saw, with twelve blades,
1 Set Pipe Taps and Dies,
1 Set Bolt Taps and Dies,
6 Cold Chisels, assorted sizes,
2 Machinists' Hammers,
2 Sledges,
2 Switch Chains,
2 Re-railing Frogs,
2 Ball-Bearing Jacks,
1 Siphon, complete,
1 Axe,
1 Hand Saw,
1 Set Triple Blocks, with rope,
2 Lining Bars,
1 Pinch Bar,
6 Shovels,
6 Picks,
1 Coal Scoop,
1 Flue Cleaner,
1 Fire Hoe,
1 Clinker Hook,
1 Slash Bar,
2 Hand Lanterns,
2 Torches,
Assortment of Packing,
Assorted Oil, in cans.

*METHODS OF HANDLING STEAM SHOVEL WORK.

DUMP CARS.

Gage of track for dump cars: Standard (4 ft. 8½ in.).

Style and capacity of cars for cut under six feet, haul less than one mile: Six (6) yard dump car.

Style and capacity of cars for cut under six feet, haul one to six miles or over: Standard car with permanent sides, with swinging hinged doors, and cars connected by aprons.

Style and capacity of cars for cut over six feet, haul less than one mile: Six (6) yard dump car.

Style and capacity of cars for cut over six feet, haul one to six miles or over: Standard car with permanent sides, with swinging hinged doors, and cars connected by aprons.

FLAT CARS.

The following points should be observed in the selection of flat cars for steam shovel work:

(1) Car should be strong enough for the purpose.

(2) Brake-wheels should be in good condition, and in case material is to be plowed off, they should be placed at side of car.

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*Adopted, Vol. 8, 1907, pp. 302-306, 346-349, 350.

(3) Stake pockets should be in good condition and not spaced too far apart. Four feet apart in center of car and closer at ends is good practice.

(4) Stakes should be strong enough to prevent accident or derailment of plow.

PLOWS AND SPREADERS.

Where dirt is dumped from trestle in fill for haul less than two miles, light cars and light trestles are recommended.

For handling unloading plows, a cable with an auxiliary engine and drum is recommended. The machine should be able to develop sixty (60) ton pull, and weigh about 28 tons; steam cylinders, 12 in. x 12 in.; diameter of drum, 4½ ft., permitting four wraps of 1½ in. cable to be made.

When raising track, the center plow is recommended when raise is light; side plows are recommended for making heavy fills.

A strong plow with trailer is recommended; it should be not less than four and one-half (4½) ft. high and thirty-six (36) ft. in length over all.

Weight of plow: Seven (7) tons.

Size and length of cable: One and one-half (1½) in. in diameter and 1,200 ft. in length.

Form of spreader: Two-arm.

Method of handling spreader: Air.

Spread of wings: Twenty (20) ft.

Limiting angle of wings: Forty-five (45) degrees.

Height above rail at which spreader should deposit material: Two (2) ft.

Depth below rail at which spreader should work: Two (2) ft.

VERTICAL LIMITS.

In making embankments with trains on new location, the following vertical limits are recommended for the respective conditions:

(1) For raising track with material dumped: Four (4) ft.

(2) For a central core put up by teams and widened with shovel material: not to exceed four (4) ft.

(3) For temporary filling trestle: Under ordinary conditions, temporary trestle for fills over four (4) ft. in height.

In making embankments with trains in present location of track under traffic, under ordinary conditions, where sand, gravel or cinders can be used, it is economical to jack main track vertically in place if raise does not exceed four (4) ft.

Where traffic is heavy and track is to be raised more than four (4) ft., it is economical to carry traffic over a temporary track built on one side while the main track is jacked vertically in place.

Where raise of track is to exceed six (6) ft., it is economical to throw main track to one side and build trestle.

*ALLOWANCE FOR SHRINKAGE IN EMBANKMENTS.

For green embankments, shrinkage allowance should be made for both height and width.

The shrinkage allowance should be as follows:

For black dirt, trestle filling: Fifteen per cent. (15%).
For black dirt, raising under traffic: Five per cent. (5%).
For clay, trestle filling: Ten per cent. (10%).
For clay, raising under traffic: Five per cent. (5%).
For sand, trestle filling: Six per cent. (6%).
For sand, raising under traffic: Five per cent. (5%).

†STEAM SHOVEL REPORT FORMS.

Three blank forms are recommended for reporting results of steam shovel work:

Form M. W. 100. Daily Steam Shovel Report.
Form M. W. 101. Monthly Steam Shovel Report.
Form M. W. 102. Record of Steam Shovel Work.

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* Adopted, Vol. 8, 1907, pp. 307, 308, 349, 350.
† Adopted, Vol. 8, 1907, pp. 309-311, 349.

Size 8x13 inches. Form M.W. 100

A. B. & C. R. R. Co.

DAILY STEAM SHOVEL REPORT

Steam Shovel No.____________at______________________ ______________________190___

Face of Bank______________________ Average Length of Haul______________________

DETAILS OF LABOR.

Steam Shovel Crew Commenced Work M

" " " Quit " M

	HOURS	RATE	AMOUNT
S. S. Engineer			
" Fireman			
" Cranesman			
" Watchman			
" Pitmen			
Car Repairers			
Laborers			
Pumpmen			
TOTAL			

Spotting Crew Commenced Work M

" " Quit " M

Engine No.			
" "			
" "			
Conductor			
Brakeman			
Engine Watchmen			
Superintendence, etc.			
TOTAL			
GRAND TOTAL			

CARS LOADED.

	CAPACITY IN YARDS	No. CARS	YDS. PER CAR	TOTAL YARDS
Hart Convert. 34' 80,000	35.6 side			
34' 80,000	25.3 center			
Rodgers, 34' 100,000	29.3			
34' 80,000	29.3			
34' 40,000				
Haskell & Barker, 40' 80,000	36.20			
Ingoldsby, 42½' 100,000	42.4			
Flats 80,000	29.3			
60,000	22			
50,000	18.3			
40,000	14.7			
Coal 60,000	36			
50,000	32.5			
40,000	23			
6 Yd. Dump Cars	6			
5 Yd. Dump Cars	5			
TOTAL				

Loads Left Over from Previous Day

Average Cost per Cubic Yard for Labor

" " " " " " Material

TOTAL Average Cost per Cubic Yard

SUPPLIES, LOCOMOTIVES, CARS, ETC.

	QTS.	PINTS	COST		QTS.	PINTS	COST
Valve Oil				Coal Loco.			
Engine Oil				Waste C. C.			
Car Oil				" Wool			
Signal Oil							
Headlight Oil							
Coal Shovel				TOTAL			

Kind of Material Handled

Character of Work Performed

Track Conditions

General Conditions

Weather

DELAYS

	HOURS	MIN.	Remarks
Waiting for Cars			
Moving Shovel			
Repairing "			
" Locomotive			
Other Delays			
TOTAL Delays			

______________________(Signature.)

Size 8x13 inches. Form M.W. 101

A. B. & C. R. R. Co.

MONTHLY STEAM SHOVEL REPORT.

Steam Shovel No............at.........................Month..................

Average Face of Bank..................Average Length of Haul................

General:	
Number of Days Worked	
Average Daily Car Output	
Average Cubic Yards per Car	
Total Cubic Yards	
Average Cubic Yards per Day	
Actual Time Worked by Steam Shovel	
Time Delayed	
Percentage of Delays	
Number and Kind of Cars Used	
Number and Kind of Engines	
Kind of Material	
Character of Work Performed	
Track Conditions	
General Conditions	
Weather	

	Total.	Per Day.	Per Yard.
Labor:			
Cost Shovel Service			
Cost Train Service			
Cost Car Repairs			
Cost Dumping Cars			
Cost of Superintendence and Plant Rental			
TOTAL Cost Labor			

	Total Cost.	Used Per Day.	Cost Per Day.
Supplies:			
Valve Oil			
Engine Oil			
Car Oil			
Signal Oil			
Headlight Oil			
Coal for Shovel			
Coal for Engine			
Waste C. C. and Wool			
TOTAL Supplies			

	Per Yard.	Per Day.
Total:		
Total Cost Labor		
Total Cost Supplies		
Total Cost Steam Shovel Work		

Size 8x13 inches. Form M.W. 102

A. B. & C. R. R. Co.

RECORD OF STEAM SHOVEL No..........

From..................M............190...to............M............190...

Engineer.............................. Cranesman.......................

Material...........................Average Haul Stations....................

Locomotive No.................Cars No............... Size................

Total Minutes Loading......No. Cars.....Minutes Per Car......No. Dippers......

Seconds Per Dipper...................Approximate Yardage...................

Total Minutes Moving.......... No. Moves.......... Minutes Per Move.........

Minutes Delays Waiting for Cars............ Weather.........................

Other Delays (Minutes)............General Conditions.........................

Total Hours Worked............Hours Lost.......... Total Hours on Duty......

Cause Hours Lost..

Shovel Moved and Ready.	Shovel Began Loading.	Delays Waiting for Cars.	Finished Loading and Ready to Move.	Time Loading.	Cars.	Dippers.	Time Moving.	OTHER DELAYS.			Cause of Delay and Remarks.
								From	To		
Time.	Time.	Mins.	Time.	Mins.	No.	No.	Mins.	Time.	Time.	Mins.	
Totals											

....

Inspector.

*GRADE REDUCTION WORK.

(1) *Organization.*—The simplest organization is preferable. One man should be in responsible charge of the work, with a staff of engineers and supervisors to cover the work; the latter should have control of men, material and means necessary for the sections respectively under them.

(2) The lowest gradient and lightest curvature which physical conditions and the present and prospective business of the railway will warrant should be established.

(3) The location should be completed before entering on the work of construction.

(4) Surface and waterway drainage should be given first consideration; and, lastly, the roadway drainage in excavations.

(5) The grades of railways and highways should be separated wherever practicable.

(6) Temporary bridges should be eliminated by the substitution of permanent structures.

(7) Light, short haul and preparatory work should be done with teams or other light working plant.

(8) Separate tracks for work and traffic should be provided where conditions warrant.

(9) There should be a well-defined plan for conducting heavy excavation before starting work.

†TRACK ELEVATION WORK.

(1) *Organization.*—A Superintendent of Construction should be in complete charge of the work. The following officers in charge of the various branches of the work should report to him: The Engineers, having charge of the contract work and giving lines and grades; the Roadmaster, in charge of earth work and track work; the Engineer, in charge of masonry and bridges; the Yardmaster, in charge of engines and switching. An Assistant Trainmaster, with a Dispatcher, in charge of the operation of traffic over the territory covered by the work in hand, may sometimes be required. If the proportions of the work permit, every

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*Adopted, Vol. 9, 1908, pp. 608, 609, 642-648.
†Adopted, Vol. 9, 1908, pp. 591, 631-642.

person connected with the organization should be relieved from all other duties relating to the operation of the railway.

(2) The railway company should handle with its own forces all work which may interfere with the movement of trains.

(3) As far as practicable, all earth work should be handled by machinery.

(4) The best material for use in filling is that which combines low first cost, ease of handling and stability.

(5) Bridge work, both railway and highway, should ordinarily consist of temporary bridges, to be replaced by permanent bridges after tracks are elevated or depressed.

(6) Water, sewer and gas pipes, electrical conduits and wires should be taken care of and the work of moving them should be done by the companies owning them, whether or not the expense is borne by the railway company.

* WATERWAYS.

(1) In determining the size of a given waterway, careful consideration should be given to local conditions, including flood height and flow, size and behavior of other openings in the vicinity carrying the same stream, characteristics of the channel and of the watershed area, climatic conditions, extent and character of traffic on the given line of railway and probable consequences of interruptions to same, and any other elements likely to affect the safety or economical construction or maintenance of the culvert or opening.

(2) *(a)* The practice of using a formula to assist in fixing the proper size of the waterway in a given case is warranted to the extent that the formula and the values of the terms substituted therein are known to fit local conditions.

(b) Waterway formulas are also useful as a guide in fixing or verifying bridge and culvert areas, where only general information as to local conditions is at hand.

(c) The use of such formulas should not displace careful field observation and the exercise of intelligent judgment on the part of the engineer.

(d) No single waterway formula can be recommended as fitting all conditions of practice.

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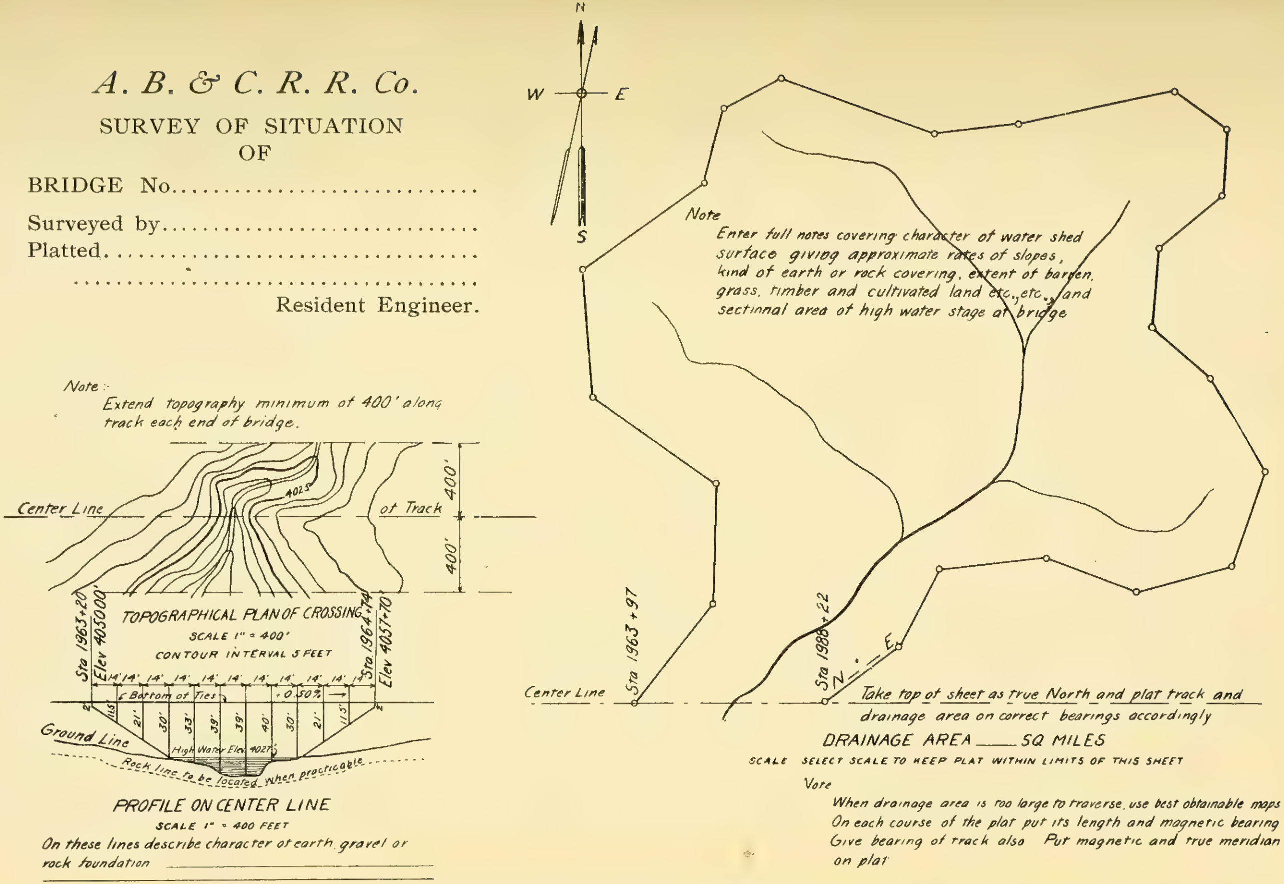
*Adopted, Vol. 10, Part 2, 1909, pp. 920, 921, 967-1022, 1097-1099.



A. B. & C. R. R. Co.

SURVEY OF SITUATION
OF

BRIDGE No............................

Surveyed by............................

Platted...................................

....

Resident Engineer.

Note:
Extend topography minimum of 400′ along track each end of bridge.

TOPOGRAPHICAL PLAN OF CROSSING
SCALE 1″ = 400′
CONTOUR INTERVAL 5 FEET

PROFILE ON CENTER LINE
SCALE 1″ = 400 FEET

On these lines describe character of earth, gravel or rock foundation

Note
Enter full notes covering character of water shed surface giving approximate rates of slopes, kind of earth or rock covering, extent of barren, grass, timber and cultivated land etc., etc., and sectional area of high water stage at bridge

Take top of sheet as true North and plat track and drainage area on correct bearings accordingly

DRAINAGE AREA ____ SQ MILES

SCALE SELECT SCALE TO KEEP PLAT WITHIN LIMITS OF THIS SHEET

Note
When drainage area is too large to traverse, use best obtainable maps
On each course of the plat put its length and magnetic bearing
Give bearing of track also Put magnetic and true meridian on plat

N
W
E
S
Center Line
of Track
400′
400′
4025
Sta 1963+20
Elev 405000′
Sta 1964+74
Elev 4057+70
14′
Bottom of Ties
+0.50%
11.5′
21′
30′
33′
39′
39′
40′
30′
21′
11.5′
Ground Line
High Water Elev 4027
Rock line to be located when practicable
Center Line
Sta 1963+97
Sta 1988+22
N
E

Illustration of Field Observations Necessary for Determining Size of Waterways.

* SLIDES.

(1) Each slide should be considered as a problem by itself.

(2) The cause of the slide should be sought. The removal or prevention of the cause is as important as the restoration of the roadway.

(3) Piles or retaining walls for the prevention and cure of slides are not recommended; but their use is permissible for temporary repairs and in special cases.

(4) Underground water should be drained away or intercepted before it reaches the slide.

(5) The surface of the slide and the restored roadway should be graded so that water will run off and not lie in pools. The surface may be compacted or sodded.

(6) The flattening of the slope is the most economical and permanent method of curing a sliding embankment.

(7) The weighting of the toe of the slope to restore equilibrium may sometimes be found efficient.

(8) The removal of the material is nearly always the most economical and permanent method of curing a slide in excavation.

(9) A relocation of the line is sometimes necessary where the slide takes the proportion of an avalanche.

†WASHOUTS.

(1) The ends of trestles and bridges should be protected with masonry, riprap or other efficient means.

(2) Where possible, track should be raised above height of flood waters and carried on strong and stable roadbed.

(3) The track on an embankment subject to overflow should be ballasted with heavy angular ballast and anchored, and the lower slope of the embankment protected with riprap.

(4) On bridges subject to overflow the track should be anchored.

(5) If the velocity of the water carries away the riprap or other protection against scour, the width of the opening should be increased.

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*Adopted, Vol. 10, Part 2, 1909, pp. 921, 1023-1093, 1099-1104; Vol. 11, Part 2, 1910, pp. 1064, 1087.

†Adopted, Vol. 10, Part 2, 1909, pp. 921, 1023-1093, 1099-1104.

*SURFACE AND SUB-SURFACE DRAINAGE.

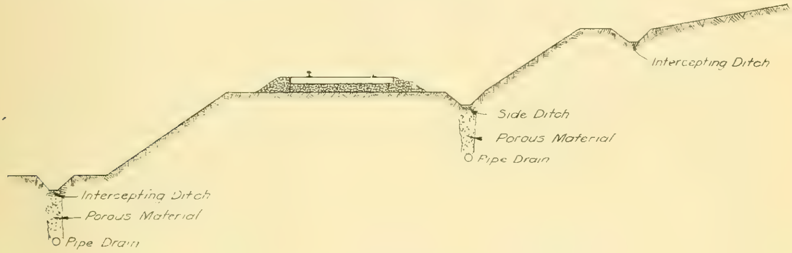
(1) As far as possible water should be kept off the roadbed.

(2) Intercepting ditches should be constructed for the protection of cuts.

(3) Intercepting ditches or pipe drains should be provided for the protection of banks built on saturated soils.

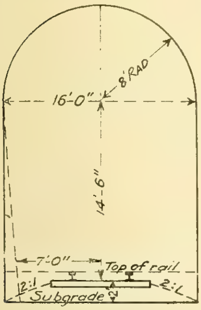
(4) Side ditches should be constructed in cuts through all classes of materials.

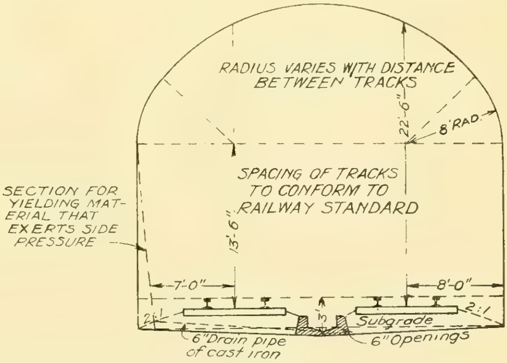
(5) Pipe drain should be provided for the drainage of wet cuts.


Intercepting Ditch
Side Ditch
Porous Material
Pipe Drain
Intercepting Ditch
Porous Material
Pipe Drain

†TUNNELS.

(1) The forms and dimensions of the clear space to be provided for single and for double-track tunnels on tangent should conform to the following diagrams (the height of rail in all cases to be assumed as 6 in.):


16'-0"
8'RAD
14'-6"
7'-0"
Top of rail
2:1
2:1
Subgrade


RADIUS VARIES WITH DISTANCE BETWEEN TRACKS
22'-6"
8'RAD
SPACING OF TRACKS TO CONFORM TO RAILWAY STANDARD
SECTION FOR YIELDING MATERIAL THAT EXERTS SIDE PRESSURE
13'-6"
7'-0"
8'-0"
2:1
2:1
Subgrade
6"Drain pipe of cast iron
6"Openings

(2) For tunnels on curved track, the dimensions of the section should be increased and the track displaced from center of tunnel so as to give

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*Adopted, Vol. 10, Part 2, 1909, pp. 921, 922, 1094-1096, 1104-1106.

† Adopted, Vol. 11, Part 2, 1910, pp. 1065-1097; Vol. 12, Part 3, 1911.

substantially the same clearance as is given on tangent by the sections above.

(3) For a double-track tunnel drainage should be provided by the construction of a concrete channel midway between the tracks.

(4) Concrete should be used for the permanent tunnel lining, except where local conditions will injure the concrete before there is time for it to harden.

In the event that a brick lining be used, that portion of the arch for a horizontal distance of five feet on each side of the center line of each track, should be laid with vitrified brick in rich Portland cement mortar.

COMMITTEE II.

BALLAST.

*DEFINITIONS.

Ballast.—Selected material placed on the roadbed for the purpose of holding the track in line and surface.

Stone Ballast.—Stone broken by artificial means into small fragments of specified sizes.

Chats.—Tailings from mills in which zinc and lead ores are separated from the rocks in which they occur.

Gravel.—Small worn fragments of rock occurring in natural deposits that will pass through a 2½-in. ring and be retained upon a No. 10 screen.

Sand.—Any hard, granular, comminuted rock which will pass through a No. 10 screen and be retained upon a No. 50 screen. No 10 0.073 = $\frac{1}{14}$" 0.011

Chert.—An impure flint or hornstone occurring in natural deposits.

Cinders.—The residue from the coal used in locomotives and other furnaces.

Slag.—The waste product, in a more or less vitrified form, of furnaces for the reduction of ore; usually the product of a blast furnace.

Burnt Clay.—A clay or gumbo which has been burned into material for ballast.

Gumbo.—A term commonly used for a peculiarly tenacious clay, containing no sand.

Disintegrated Granite.—A natural deposit of granite formation, which, on removal from its bed by blasting or otherwise, breaks into particles of size suitable for ballast.

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*Adopted, Vol. 5, 1904, pp. 486, 495, 498-501; Vol. 6, 1905, pp. 736, 745; Vol. 7, 1906, pp. 83, 84, 88, 100; Vol. 10, Part 1, 1910, pp. 678, 721-727.

*CHOICE OF BALLAST.

While there is great variation in the qualities of the different natural materials for ballast, the choice of these qualities is not usually left to the engineer, but has already been made by nature, and the decision must be as to what is most available or expedient, and should be according to circumstances. Financial questions may be the ruling consideration, or there may be but one material obtainable.

In the case of crushed stone, however, the process of manufacture being under control, it is practicable to make the product conform to specifications.

†SPECIFICATIONS FOR STONE BALLAST.

1. Stone ballast shall be sufficiently durable not to disintegrate in the climate where used, hard enough to prevent pulverizing unduly under the action of tools or traffic, and shall break with an angular fracture when crushed.

2. It shall be broken into pieces of such size that they will in any position pass through a 2½-in. ring and will not pass through a ¾-in. ring.

3. It shall be free from dirt, dust or rubbish.

‡SPECIFICATIONS FOR GRAVEL BALLAST.

For Class A Roads: When bank gravel contains more than two (2) per cent. of dust or forty (40) per cent. of sand, it should be washed or screened. Washed or screened gravel should contain not less than twenty-five (25) per cent. nor more than thirty-five (35) per cent. sand.

For Class B Roads: When bank gravel contains more than three (3) per cent. of dust or sixty (60) per cent. of sand, it should be screened or washed. Washed or screened gravel should not contain less than twenty-five (25) per cent. nor more than fifty (50) per cent. of sand.

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*Adopted, Vol. 5, 1904, pp. 494, 495, 513, 514; Vol. 6, 1905; pp. 736, 737.

† Adopted, Vol. 5, 1904, pp. 487, 495, 501-505; Vol. 6, 1905, pp. 737, 745; Vol. 11, 1910, pp. 907, 930, 931.

‡ Adopted, Vol. 11, 1910, pp. 909, 931, 932.

For Class C Roads: Any material which makes better track than the natural roadbed may be economically used.

"The term "percentage" above is used to indicate the proportion of the original bulk.

*CINDER AND BURNT CLAY BALLAST.

Cinder Ballast.—The use of cinders as ballast is recommended for the following situations: On branch lines with light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; as sub-ballast on new work where dumps are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn.

Burnt Clay Ballast.—The material should be black gumbo or other suitable clay free from sand or silt. The suitability of the material should be determined by thorough testing in a small test kiln before establishing a ballast kiln.

The material should be burnt hard and thoroughly.

The fuel used should be fresh and clean enough to burn with a clean fire. It is important that a sufficient supply be kept on hand to prevent interruption of the process of burning.

Burning should be done under the supervision of an experienced and competent burner.

Burnt clay ballast should be allowed to cool before it is loaded out of the pit.

Absorption of water should not exceed fifteen (15) per cent. by weight.

†PHYSICAL TEST OF STONE BALLAST.

It is recommended that the following be used for physical tests of stone ballast:

(*a*) Weight per cubic foot.

(*b*) Water absorption in pounds per cubic foot.

(*c*) Per cent. of wear.

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* Adopted, Vol. 6, 1905, pp. 737, 738, 745, 746; Vol. 7, 1906, pp. 84, 85, 90, 91, 92, 100.

† Adopted, Vol. 11, Part 2, 1910, pp. 914, 932.

(*d*) Hardness.

(*e*) Toughness.

(*f*) Cementing value.

It is also recommended that the "Specific gravity" and the "French coefficient of wear" shall not be included in the physical tests of stone ballast, as practically the same information is given in the other tests above mentioned.

*CLEANING FOUL BALLAST.

Under usual conditions no ballast, except stone or hard slag, should be cleaned.

Clean with ballast forks.

Clean shoulder down to sub-grade.

Clean between ties to bottom of ties.

Clean center ditch of double-track to sub-grade.

Return clean ballast.

Stone Ballast should be cleaned: In terminals, at intervals of one (1) to three (3) years. Heavy traffic, coal and coke lines, at intervals of three (3) to five (5) years. Light traffic lines, at intervals of five (5) to eight (8) years.

Per cent. of new stone ballast to be applied: Fifteen (15) to twenty-five (25) per cent.

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* Adopted, Vol. 11, Part 2, 1910, pp. 915, 932, 933.

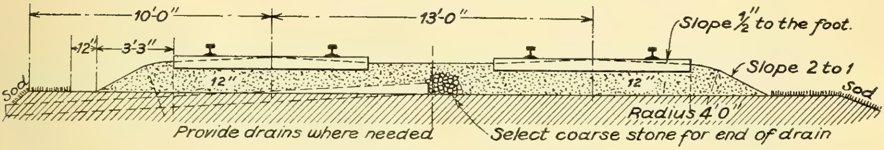
*BALLAST SECTIONS.

The following ballast sections illustrate good practice.

The sections for Class A track are intended to show minimum depth under ties, and are recommended for use only on the firmest, most substantial and well-drained sub-grades.

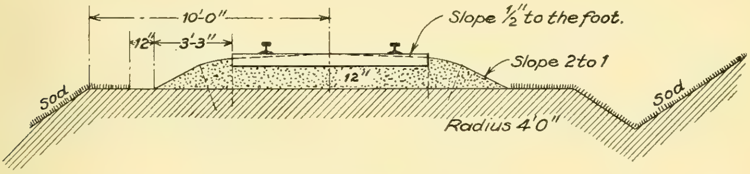
The sodding of the roadbed shoulder next to ditch and of the slopes of the ditch is recommended.

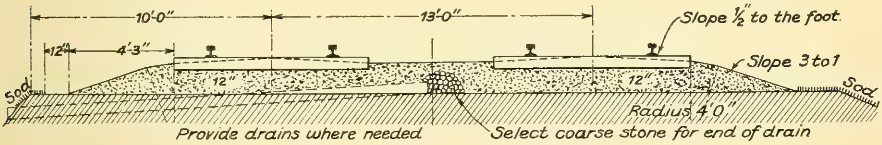
CLASS A.

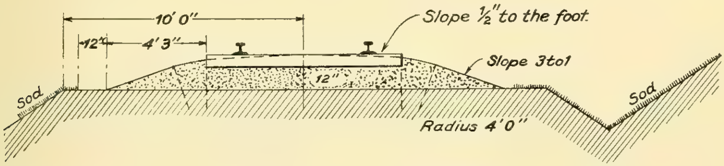

10'-0"
13'-0"
Slope ½" to the foot.
12"
3'-3"
Slope 2 to 1
Sod
12"
12"
Sod
Radius 4'0"
Provide drains where needed
Select coarse stone for end of drain

Crushed Stone and Slag.

NOTE.—The slag is broken and similar in its character to crushed stone. Granulated slag should be dressed to section shown for Gravel, Cinders and Chats.


10'-0"
Slope ½" to the foot.
12"
3'-3"
Slope 2 to 1
12"
Sod
Sod
Radius 4'0"


10'-0"
13'-0"
Slope ½" to the foot
12"
4'-3"
Slope 3 to 1
Sod
12"
12"
Sod
Radius 4'0"
Provide drains where needed
Select coarse stone for end of drain


10'0"
Slope ½" to the foot
12"
4'3"
Slope 3 to 1
12"
Sod
Sod
Radius 4'0"

Gravel, Cinders and Chats.

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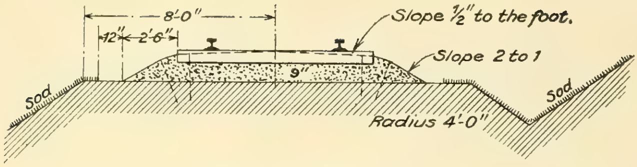
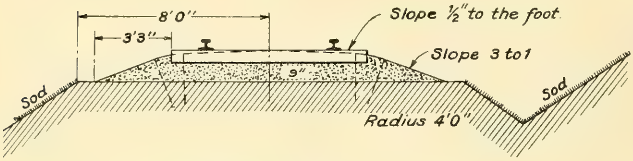
*Adopted. Vol. 8. 1907 pp. 44-46, 62, 65, 66, 67; Vol. 9, 1908, pp. 309, 311, 312.

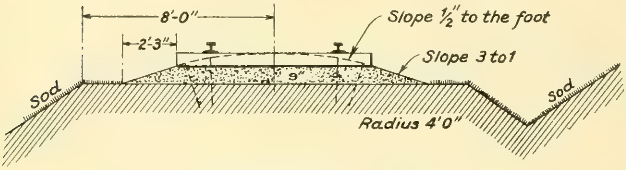
CLASS B.


8'-0"
12"
2'-6"
Slope ½" to the foot.
Slope 2 to 1
9"
Sod
Sod
Radius 4'-0"

Crushed Stone and Slag.

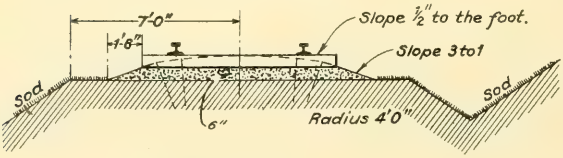

8'0"
3'3"
Slope ½" to the foot
Slope 3 to 1
9"
Sod
Sod
Radius 4'0"

Gravel, Cinders and Chats.

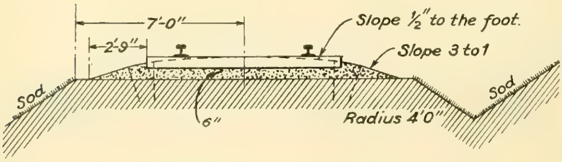

8'-0"
2'-3"
Slope ½" to the foot
Slope 3 to 1
9"
Sod
Sod
Radius 4'0"

Gravel, Cinders and Chats.

CLASS C.


7'-0"
1'-8"
Slope ½" to the foot.
Slope 3 to 1
6"
Sod
Sod
Radius 4'0"

Cementing Gravel and Chert.


7'-0"
2'-9"
Slope ½" to the foot.
Slope 3 to 1
6"
Sod
Sod
Radius 4'0"

Cementing Gravel and Chert.

COMMITTEE III.

TIES.

* DEFINITIONS.

Cross-Tie.—The transverse member of a railway track supporting the rails by means of which they are retained in position.

Pole Tie.—A tie made from a tree of such size that not more than one tie can be made from a section; hewn or sawn on two parallel faces.

Split Tie.—A tie made from a tree of such size that by splitting two or more ties can be made from a section.

Slab Tie.—A tie made from slabs.

Sawed Tie.—A tie having both faces and sides sawed.

Quartered Tie.—A tie made from a tree of such size that four ties only are made from a section.

Half-Round Tie.—A slabbed tie having greater width on lower than on top face.

Slabbed Tie.—A tie sawed on top and bottom only.

Hewed Tie.—A tie hewed on at least two sides.

Sap Tie.—A tie which shows more than the prescribed amount of sapwood in cross-section.

Heart Tie.—A tie showing sapwood on one or two corners only and which sapwood does not measure more than one inch on either corner, on lines drawn diagonally across the end of tie.

Strict Heart Tie.—A tie having no sapwood.

Wane Tie.—A squared tie showing part of the original surface of the tree on one or more corners.

Doty Tie.—A tie affected by fungous disease.

Pecky Tie.—A tie made from a cypress tree affected with a fungous disease, known locally as peck.

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* Adopted, Vol. 5, 1904, pp. 73, 74, 78, 106-120, 131, 132; Vol. 6, 1905, pp. 766, 767; Vol. 7, 1906, pp. 33, 37, 66; Vol. 11, Part 2, 1910, pp. 863, 901.

Tapped Tie.—A tie made from a tree, the resin or turpentine of which has been extracted before felling.

Score Mark.—A mark made by the axe as an aid in hewing.

Shakes.—Separations of the wood fiber, due to the action of the wind.

Checks.—Small cracks in the wood due to seasoning.

Face.—The upper or lower plane surface of a tie.

*SPECIFICATIONS FOR CROSS-TIES.

Woods to Be Used Untreated.

1. The following woods may be used for tie timber without preservative treatment:

White Oak family.
Long-leaf strict heart yellow pine.
Cypress, excepting the white cypress.
Redwood.
White Cedar.
Chestnut.
Catalpa.
Locust, except the honey locust.
Walnut.
Black Cherry.

Woods to Be Treated.

2. The following woods shall preferably not be used for tie timber without a preservative treatment approved by the purchaser:

Red Oak family.
Beech.
Elm.
Maple.
Gum.
Loblolly, short-leaf, lodgepole, Western yellow pine, Norway, North Carolina pine and other sap pines.
Red Fir.
Spruce.
Hemlock.
Tamarack.

Material and Manufacture.

3. Cross-ties shall be well and smoothly hewed or sawed out of straight, growing timber of specified dimensions and out of wind, sawed

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*Adopted, Vol. 5, 1904, pp. 72, 73, 78, 120-132; Vol. 6, 1905, pp. 763-766; Vol. 7, 1906, pp. 34-36, 65, 66.

ends, with straight and parallel faces, the minimum width of either face to be not less than that given in the table of dimensions. Ties shall have bark entirely removed before being delivered on the company's ground. They shall be free from splits, shakes, loose or decayed knots, or any other imperfections which may impair their strength or durability.

Dimensions.

4. Except in pole ties with rounded sides, or in half-round ties, none shall be less than eight (8) in. width of face, and in no tie shall the thickness be less than six (6) in. A variation in size will be permitted of one-half (½) in. over in thickness, two (2) in. over in width and one (1) in. over in length.

Allowable Variation in Pole Ties.

5. In pole ties with rounded sides and half-round ties, the width of face may be less than that given in the table of dimensions, but the least area of cross-section shall be not less than the area corresponding to the tabular dimensions, and in no case shall the width of face be less than six (6) in.

TABLE OF DIMENSIONS.

Class	Thickness by Width of Face	Length		
	Inches	Feet	Feet	Feet
A	7 x 10	8	8½	9
B	7 x 9	8	8½	9
C	7 x 8	8	8½	9
D	6 x 9	8	8½	9
E	6 x 8	8	8½	9

Piling Untreated Ties.

6. Ties which are delivered along the right-of-way of the railway shall be piled at station yards or at points between stations designated in the contract, not less than ten (10) ft. from the nearest rail; each pile to be of either 25 or 50 ties, built with two ties on the ground and above in alternate courses of 7 and 2, except the top, which shall be placed to form a watershed, as shown in diagram. Each pile shall be

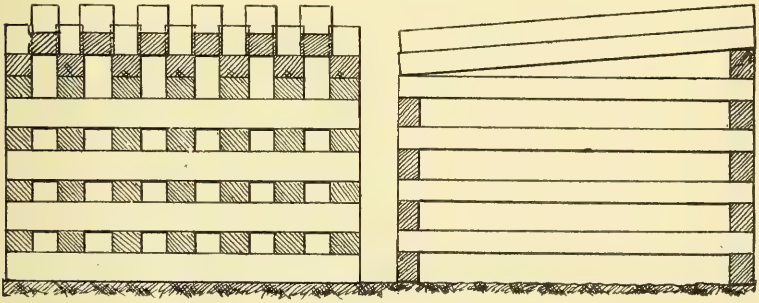

FIG. 1. PILING DIAGRAM FOR FIFTY TIES.

plainly marked with the owner's name and date when piled. Three feet of space shall be left between piles to permit inspection. Sawed ties shall be piled separately from hewed ties.

Removal of Rejected Ties.

7. All rejected ties shall be removed from the company's right-of-way within ten days after notice is given.

Piling Treated Ties.

8. Ties treated with a water solution, like zinc-chloride, particularly red oak and beech ties, shall be piled in close piles on well-drained ground, to prevent checking.

Time of Cutting.

9. Ties shall be cut, as far as possible, in the winter period; that is, from October to March.

*CONSERVATION OF TIMBER SUPPLY.

(1) The use of chemically treated ties wherever practicable is recommended.

(2) Ties should be protected from failure against mechanical wear by means of tie plates and screw-spikes.

(3) The tie specifications should be rigidly enforced with particular reference to the exclusion of small ties.

(4) There should be co-operation among the railways in any given territory looking toward the adoption of standard tie specifications, with particular reference to making it impossible for contractors to furnish ties cut from small trees which would naturally form sources for future tie supplies.

(5) Measures should be adopted for reducing forest fires.

(6) Owners should be encouraged to re-forest their lands either by re-planting or natural reproduction.

(7) Proper means should be used to aid and assist in the investigation of tax laws as far as they pertain to forest lands, with a view to having legislation enacted which would make it possible to hold lands with growing timber for the purpose of future tie production.

(8) The species of trees to be grown should be selected only after careful and expert study of the available soils and climate.

(9) Where plantations are made, they should be of such extent as to warrant a maintenance appropriation sufficient to insure proper attention.

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* Adopted, Vol. 10, 1909, pp. 490, 493, 494, 521-528; Vol. 11, 1910, pp. 863, 901.

*USE OF DATING NAILS.

(1) A dating nail should be driven in the upper side of every treated tie ten inches inside of the rail, and on the line side of the track. The tie should be laid with the end having the year stamped on it on the line side of the track. Dating nails should be driven the same day the tie is put in.

(2) Section foremen should be especially careful to see that the marks or nails intended to identify the ties are not injured or destroyed.

(3) In addition to the use of the dating nail, each tie should be stamped with the year, at the treating plant, before treatment, and, preferably, should be stamped on both ends.

† SPECIFICATIONS FOR DATING NAIL.

1. The nail shall be made of iron or steel, galvanized with a coating of zinc, evenly and uniformly applied, so that it will adhere firmly to the surface of the steel; it shall be ¼-in. in diameter, 2½ in. in length, with head ⅝-in. in diameter, having stamped therein two figures designating the year; the figures to be ⅜-in. in length and depressed into the head $\frac{1}{16}$-in. **Material.**

2. Any specimen shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute and then removed, immediately washed in water thoroughly, and wiped dry; this process shall be repeated. If after the fourth immersion there is a copper-colored deposit on the sample, or the zinc has been removed, the lot from which the sample was taken shall be rejected. **Test.**

3. The standard solution of copper sulphate shall consist of a solution of 34.5 parts of crystallized copper sulphate in 100 parts of water. This solution shall have a specific gravity of 1.185 at 70 degrees Fahrenheit. While a sample is being tested, the temperature of the standard solution shall at no time be less than 60 degrees Fahrenheit nor more than 70 degrees Fahrenheit. **Chemicals.**

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* Adopted, Vol. 7, 1906, pp. 37, 67; Vol. 11, Part 2, 1910, pp. 863, 901.

† Adopted, Vol. 7, 1906, pp. 38, 67, 68; Vol. 11, Part 2, 1910, pp. 863, 901.

*RECORDS OF CROSS-TIES.

Form M. W. 300, "Foreman's Monthly Tie Removal Report," is recommended as the proper blank to be used by the Section Foreman for reporting the information required for form M. W. 303. This form can also be used for reporting any cross-tie removals when the ties are marked in such a way as to indicate the year laid.

Form M. W. 301, "Statistics of Cross-Tie Renewals," is intended for general statistical information concerning the life and cost of cross-ties in use on a division, regardless of the kinds of timber, except in a general way.

Form M. W. 302, "Comparison Between Different Kinds of Wood," is a more detailed comparison between the different kinds of woods and preservative processes, and will explain, in many cases, why the life of ties on one railway is longer than on another.

Form M. W. 303, "Life Record of Ties," gives the life record of ties.

Form M. W. 304, "Statistics of Treated Ties," is intended to give full details concerning the preservation of cross-ties.

Size, 8x13 inches. Form M. W. 300.

A., B. & C. R. R. Co.

FOREMAN'S MONTHLY TIE REMOVAL REPORT

Section No.................. Division................ Month of.....................19....

Removed from Main Tracks					Removed from Side Tracks			
		Kind of					Kind of	
Number Removed	Year Put in	Timber	Treatment*	Cause	Number Removed	Year Put in	Timber	Treatment*

After approval by..........................it is to be forwarded to.....................

....

Foreman.

This blank must be sent in monthly by all Foremen, whether any ties have been removed or not. When no ties have been removed, it must be so stated on the blank.

*Note.—When untreated ties are removed, make a dash (—) in "Treatment" column.

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*Adopted, Vol. 3, 1902, pp. 102-105, 109-113; Vol. 10, Part 1, 1909, pp. 490-492, 521.

FORM M.W. 301.

STATISTICS OF CROSS-TIE RENEWALS.

FORM M.W. 302.

COMPARISON BETWEEN DIFFERENT KINDS OF WOOD.

FORM M.W. 303.

LIFE RECORD OF TIES.

FORM M.W. 304.

STATISTICS OF TREATED TIES.

Form M. W. 301

A. B. & C. R. R. CO.

STATISTICS OF CROSS-TIE RENEWALS

For Year Ending——————19—

DIVISION (Report by Division and not by System.)	Miles of Road Operated		No. of Tons Moved One Mile During Year	Maximum Weight in Tons		Weight of Main Track Rail in lbs. per yard	Percentage of Main Track				Kind of Ballast Used. Percentage of Each	Number of Ties in Each Mile of Track		Total Number of Ties Renewed During Year		Per Cent. of Renewals to Number in Tracks			Average Cost Ties Delivered on Ground of Division		*Total Cost of Tie Renewals per Mile of Track			Average Life, Class of Wood and Cost of Cross-Ties.									Climatic Conditions on Division.		
	All Main Tracks	All Tracks Including Sidings		Locomotive and Tender	Fully Loaded Freight Car		Curved	Tie-Plated	Ballasted	Laid with Treated Ties		Main	Side	In Main Tracks	In Side Tracks	Main	Side	Total	Treated Ties	Untreated Ties	All Main Tracks	All Side Tracks	All Tracks	Main Tracks			Side Tracks			All Tracks			Temperature		Approx. Rainfall in Inches
																								Life	Class	Cost	Life	Class	Cost	Life	Class	Cost	Max.	Min.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Total for Year																																			
Total for Previous Year																																			

*To include cost of cross and switch ties, tie-plates, and spike plugs, but not the labor of placing in track.
Data for columns 25 to 33 kept on Forms M. W. 302 and 303.

Omit mileage of new tracks in which tie renewals have not been commenced, and omit number of ties used for new tracks.
Bridge ties are to be considered as track ties and included in report.

Tons of 2,000 lbs. to be used.

Form M. W. 302

A. B. & C. R. R. CO.

COMPARISON BETWEEN DIFFERENT KINDS OF WOOD

For Year Ending——————19—

DIVISION (Report by Division and not by System.)	UNTREATED																					TREATED															GRAND TOTALS			No. of Tie-plated Ties included in totals
	White Oak, Burr Oak, Chestnut Oak			CHESTNUT			PINE			CEDAR			CYPRESS			OTHER WOODS			TOTALS			PROCESS			PROCESS			PROCESS			PROCESS			TOTALS						
	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	Total in all Tracks	Total Ties Removed	Per Cent. of Renewals to Total	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Totals																																								

This blank elaborates the information in columns 25 to 33 of Form M. W. 301 and compares the value of the different woods as ties, irrespective of cost.
See Form M. W. 304 for detail information concerning "preserved" or "treated" ties.

Do not include ties in new tracks in which renewals have not yet commenced.
If the headings given do not cover the kind of ties used, change them.

Form M. W. 303.

A. B. & C. R. R. CO.

RECORD OF TIES

Data completed to——————19—

Total Cross-Ties, all kinds, laid in Track. (inc. new track.)			Total Number of the Cross-Ties Stamped for the Year in Column 1 Removed from Tracks in the Year in Columns 4 to 57 (both inclusive).																																																							Per cent. remaining in track on date of this report.		Average Life in years deduced from renewals.	
			Year.						Year.						Year.						Year.						Year.						Year.						Year.						Year.						Year.						Total Removed.					
Year	Main	Side	Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main			Side			Main	Side	Main	Side	Main	Side
			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood			Class of Wood								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	1 5	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63

This blank cannot be tabulated for several Divisions or Railroads. It must be presented for each separately, but will only be printed when considered sufficiently complete. When records have not been kept so that this can be filled out for a single year, the blank should be returned to the Secretary marked "No Data." In course of time it will be a valuable blank to all, and will be easily kept when once started. This blank furnishes the data for columns 25 to 33 of Form 1. In body of blank causes for increased or decreased life of ties as years advance should be explained. In body of blank kinds of timber used for ties and approximate percentage of each kind should be stated. Records should start with year 1888 ties, if possible; otherwise as far back as records will permit.

NOTE.—Class L includes: White Oak Family. Chestnut. Tamarack. Cedar. Locust. Cypress. Long Leaf Yellow Pine. Redwood. Catalpa. Cherry.

Class S includes: All Pine except Long Leaf. Beech. Elm. Gum. Inferior Oaks. Hemlock. Red Fir. Spruce.

Class T includes—All classes of Treated Ties.

Form M. W. 304

A. B. & C. R. R. CO.

STATISTICS OF TREATED TIES

For Year Ending——————19—

DIVISION (Report by Division and not by System.)	LIFE OF TREATED TIES IN YEARS																														Antiseptic Used	Amount Injected per Cubic Foot	Number of Treated Ties in Track this Date	Number put in Tracks this Year	AVERAGE COST PER TIE				REMARKS
	PINE					HEMLOCK					BEECH					SPRUCE																			First Cost Untreated	For Extra Handling and Transportation	For Preservative Treatment	Ready for Track	
	Process					Process					Process					Process					Process					Process													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

The life record of treated ties should be kept separately on a blank like Form M. W. 303.

COMMITTEE IV.

RAIL.

*STANDARD LENGTH OF RAIL.

The standard length of rail is 33 ft.

‡RAIL RECORD FORMS.

(1) The following forms are considered essential and are recommended for keeping rail statistics and records:

Group I—Reports of Rail Inspection and Shipment at the Mill:

Form M. W. 401, Report of Chemical and Physical Examination.

Form M. W. 402, Certificate of Inspection.

Form M. W. 403, Report of Shipment.

Form M. W. 418, Results of Drop Tests and Surface Inspection of Rails Rolled.

Group II—Reports from Division Officers:

Form M. W. 404, Report of Rail Failures in Main Tracks.

Form M. W. 405, Superintendent's Monthly Report of Rail Failures in Main Tracks.

Form M. W. 406, Annual Statement of Steel Rails Existing in Main Tracks.

Group III—Laboratory Examination of Special Rails:

Form M. W. 407, Laboratory Report of Chemical and Physical Examination of Rail and Other Track Material.

Group IV—Compilation of Results for Study:

Form M. W. 408, Summary of Steel Rail Failures for One Year Compared with the same Period of Previous Year.

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* Adopted, Vol. 2, 1901, pp. 190, 204-212.

‡ Adopted, Vol. 10, 1909, pp. 339-363, 375, 393-395; Vol. 11, Part 2, 1910, pp. 241-251, 576-579; Vol. 12, Parts 1 and 2, 1912.

Note.—The Specifications for Bessemer Steel Rails have been temporarily withdrawn for further consideration.

Form M. W. 409, Summary of Steel Rail Failures for a Period of Years.

Form M. W. 410, Comparative Number of Failures of Steel Rails of Different Section or Pattern, Rolled by Different Steel Companies.

Form M. W. 411, Position in Ingot of Steel Rails which Failed.

Form M. W. 412, Cover for forms M. W. 408, 409, 410, 411.

Group V—Progressive Wear of Special Rails under Observation:

Form M. W. 413, Location Diagram. (Scale of 1 in.=one mile.)

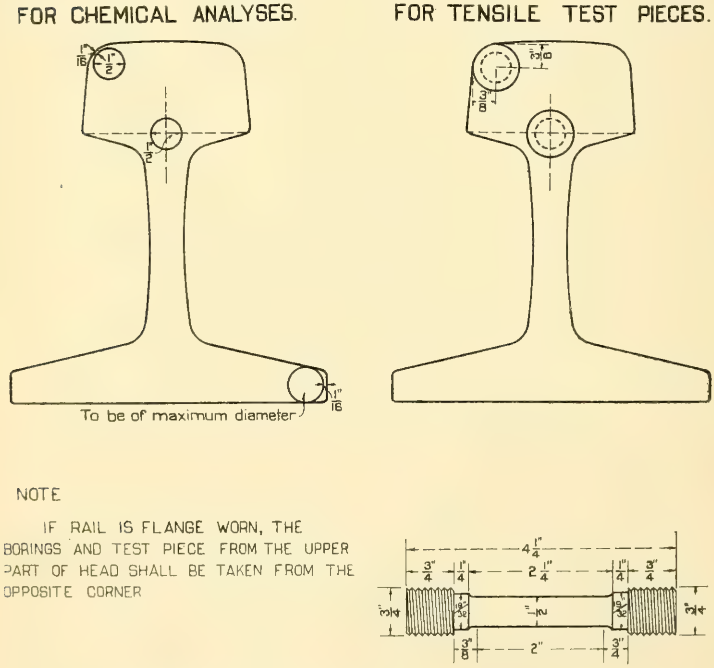
Form M. W. 414, Location Diagram. (Scale of 2 in.=one mile.)

Form M. W. 415, Diagram showing Lines of Wear.

Form M. W. 416, Record of Comparative Wear of Special Rail.

Form M. W. 417, Cover for forms M. W. 413, 414, 415, 416.

*STANDARD LOCATIONS OF BORINGS FOR CHEMICAL ANALYSES AND TENSILE TEST PIECES.


FOR CHEMICAL ANALYSES.
FOR TENSILE TEST PIECES.
1/16"
1/2"
1/2"
1/16"
To be of maximum diameter
3/8"
3/8"
4 1/4"
3/4"
1/4"
2 1/4"
1/4"
3/4"
3/4"
19/32
1/2"
19/32
3/4"
3/8"
2"
3/4"

NOTE

IF RAIL IS FLANGE WORN, THE BORINGS AND TEST PIECE FROM THE UPPER PART OF HEAD SHALL BE TAKEN FROM THE OPPOSITE CORNER

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* Adopted, Vol. 12, Parts 1 and 2, 1911.

Form M.W. 401 (Old Form 2001-A).

A. B. & C. R. R. Co.

Report of Chemical and Physical Examination

Sheet No.______
of______Sheets

of________ Rails __________________ Process __________ lbs. per yd., ________ Section
No. (Open Hearth, Bessemer or Special)

Manufactured by__________________Steel Co., at ________________________Works

For ____

Order No. ________ Date of Report ________________19____

No. of Passes in Rolls__________ Bar held on average of________seconds at________Pass.

Shrinkage Allowance at Saws____________inches on 33-ft. rails

Distance between supports on Straightening Press____________________

Weight of Tup, 2000 lbs. Height of Drop __________ft Distance between Supports, 3 ft

Average Number of Rails per Heat ____

Heat No.	Percentage of Crop from Ingot.			Carbon.	Manganese.	Phosphorus.	Silicon.	Sulphur			Drop Test Deflection Inches.	Remarks
	No. of Ingots	% from Top	% from Bottom									
												1
												2
												3
												4
												5
												6
												7
												8
												9
												10
For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures												11
7	4	5	5	5	5	5	5	5	5	5	5	11 12
				Size of sheet required, 8x10½ inches.								13
												14
												15
												16
												17
												18
												19
												20
												21
												22
												23
												24
												25
												26
												27
												28
												29
												30
												31
												32

Note—Requirements of Standard Specifications are to be stated on line 1

Instructions

One copy of this report to be forwarded to the Chief Engineer M of W

Correct ________________________
Inspector

Approved ________________________
Chief Inspector
Engineer of Tests

Form M.W. 402 (Old Form 2001-B).

A. B. & C. R. R. Co.

No.________

CERTIFICATE OF INSPECTION

of________________ Process Rails__________lbs. per yd.________________Section.
(Open Hearth, Bessemer or Special)

Manufactured by______________________Steel Co. at__________________Works

For____

Mr.________________________Chief Engineer M. of W. Date______________19___

The following Steel Rails have been inspected and accepted according to contract.

Rails are certified to be within the limits of the Specifications of the__________________

____

and approved as per details given below.

All Rails have been inspected and approved for Chemical Analysis, Physical Tests, Section, Weight, Straightening, Drilling, Sawing, Length, Stamping, Finish, Quality.

All Rails are marked on the web with maker's name, date of manufacture, Heat Number, and position occupied in the ingot.

Date of Rolling__________________

No. of Rails Rolled________________ No. of Rails Accepted________________

No. of Rails temporarily rejected and cause______________________________

____

____

No. of Rails condemned and cause_________________________________

____

____

For filling in with typewriter columns should be spaced in tenths of an inch as shown by the figures under columns. Size of sheet required, 8x10½ inches.

This Certificate covers the run from

Heat No.__________ to Heat No.__________both inclusive

Number of Rails of each Length.

Length		33	30		27½		25		Total.
Number									
7	6	6	5	4	4	4	4	4	6

8

Calculated Weight.			Shipper's Scale Weight.		
Total Pounds	Tons	Pounds	Total Pounds	Tons	Pounds
11	7	7	11	7	7

8

Trial Weights

Hours	Wts.	Hours	Wts.
6 A		6 P	
7 "		7 "	
8 "		8 "	
9 "		9 "	
10 "		10 "	
11 "		11 "	
12 M		12 M	
1 P		1 A	
2 "		2 "	
3 "		3 "	
4 "		4 "	
5 "		5 "	
5	6	5	6

Amount accepted under this Certificate__________________

Total amount of Order__________________

Balance due on Order__________________

Instructions

One copy of this Certificate is to be made out and forwarded to the Chief Engineer M. of W. of the Railway Company.

Correct.________________________
Inspector.

Approved:________________________
Chief Inspector
Engineer of Tests.

FORM M. W. 418.

RESULTS OF DROP TESTS AND SURFACE INSPECTION OF RAILS ROLLED.

Form M.W. 402 (Old Form 2001-B).

A. B. & C. R. R. Co.

No.________

CERTIFICATE OF INSPECTION

of________________Process Rails__________lbs. per yd.______________Section.
(Open Hearth, Bessemer or Special)

Manufactured by______________________Steel Co. at__________________Works

For____

Mr.______________________Chief Engineer M. of W. Date______________19___

The following Steel Rails have been inspected and accepted according to contract.

Rails are certified to be within the limits of the Specifications of the__________________

____

and approved as per details given below.

All Rails have been inspected and approved for Chemical Analysis, Physical Tests, Section, Weight, Straightening, Drilling, Sawing, Length, Stamping, Finish, Quality.

All Rails are marked on the web with maker's name, date of manufacture, Heat Number, and position occupied in the ingot.

Date of Rolling____________________

No. of Rails Rolled________________ No. of Rails Accepted________________

No. of Rails temporarily rejected and cause____________________________

____

____

No. of Rails condemned and cause______________________________________

____

____

For filling in with typewriter columns should be spaced in tenths of an inch as shown by the figures under columns. Size of sheet required, 8x10½ inches.

This Certificate covers the run from

Heat No.__________ to Heat No.__________both inclusive

Number of Rails of each Length.

Length		33	30		27½		25		Total.
Number									
7	*6*	*6*	*5*	*4*	*4*	*4*	*4*	*4*	*6*

8

Calculated Weight.			Shipper's Scale Weight.		
Total Pounds	Tons	Pounds	Total Pounds	Tons	Pounds
11	*7*	*7*	*11*	*7*	*7*

8

Amount accepted under this Certificate__________________

Total amount of Order__________________

Balance due on Order__________________

Trial Weights			
Hours	Wts.	Hours	Wts.
6 A	____	6 P	____
7 "	____	7 "	____
8 "	____	8 "	____
9 "	____	9 "	____
10 "	____	10 "	____
11 "	____	11 "	____
12 M	____	12 M	____
1 P	____	1 A	____
2 "	____	2 "	____
3 "	____	3 "	____
4 "	____	4 "	____
5 "	____	5 "	____
5	*6*	*5*	*6*

Instructions

One copy of this Certificate is to be made out and forwarded to the Chief Engineer M. of W. of the Railway Company.

Correct.__________________________
Inspector.

Approved:__________________________
Chief Inspector
Engineer of Tests.

Form M. W. 418.

A. B. & C. R. R. Co.

RESULTS OF DROP TESTS AND SURFACE INSPECTION OF RAILS ROLLED DURING

Additional Columns -

1st Average Analysis of Heats Accepted
After column 45, Sulphur, add 2 columns
without headings to be numbered 46 & 47

2nd Average Analysis of Heats Rejected
After column 52, Sulphur, add 2 columns
without headings to be numbered 53 & 54

3rd Change the numbers of
columns as shown

A

Report Numbers	Heat Numbers

These two columns are for office use in compiling the several rollings and shipments, and are to be removed on line "A" from the finished report.

A

Width 10½ inches

Lines	Name of Company and Mill where Rolled	Rail		'B' Bessemer or 'O.H.' Open Hearth	No of Tons ordered	No. of Tons Received of each Classification.										No. of Tons Rejected.		No. of Heats Rolled	Average No. of Ingots in Heat.	Average No. of Rails in Heat.	No. of Rails Rolled.
		Weight	Section			No. 1		Specials					No. 2		Total Tons	Number	% of Total Received				
						Tons	% of Total	A.	B.	C.	D.	% of Total	Tons	% of Total							
								Tons	Tons	Tons	Tons										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1																					
2																					
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					
13																					
14																					
15																					
16																					
Grand Total																					

Lines	No. of Rails Accepted and Classification							No. of Rails Rejected		No. of Rails Rejected.								No. of Rails accepted as No. 2 on account of exceeding specified deflection *	
	No. 1	Specials				No. 2	Total Rails	Number	% of Total Accepted	On account of two test pieces breaking under drop of Test (a)		Being 'A' Rails which showed interior physical defect when broken under Test (a) Test (b)		On account of failure of 'B' Rails after Rejection of 'A' Rails Test (c)		On Account of Surface Imperfection.			
	Rails	A	B.	C	D.	Rails				No	% of Total Rejected	No.	% of Total Rejected	No.	% of Total Rejected	No.	% of Total Rejected	No	% of Total Rejected
		Rails	Rails	Rails	Rails														
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
Grand Total																			

Average Analysis of Heats Accepted					Average Analysis of Heats Rejected.					% of Ingot Discarded		Permanent deflection under Drop Test.	Shrinkage allowed in inches	Effect of Retest (a)		No of Heats showing Rails with interior defect		Lines
Carbon	Mang.	Phos.	Sil.	Sulphur	Carbon	Mang	Phos	Sil.	Sulphur	From Top	From Bottom			Tons Accepted	Heats Accepted	No. of Heats	% of Total	
41	42	43	44	45	48	47	50	51	52	55	56	57	58	59	60	61	62	
																		1
																		2
																		3
																		4
																		5
																		6
																		7
																		8
																		9
																		10
																		11
																		12
																		13
																		14
																		15
																		16

NOTE:- If Specials are not accepted, columns 8, 9, 10, 11 and 23, 24, 25, 26 should be omitted.

DROP TESTS

Drop Tests shall be made on pieces of rail rolled from the top of the ingot, not less than four (4) ft. and not more than six (6) ft. long, from each heat of steel. These test pieces shall be cut from the rail bar next to either end of the top rail, as selected by the inspector.

The test pieces shall be placed head upward on solid supports, five (5) in. top radius, three (3) ft. between centers, and subjected to impact tests, the tup falling free from the following heights:

70 lb. rail	16 ft.
80, 85 and 90 lb rail	18 ft.
100 lb. rail	20 ft.

The test pieces which do not break under the first drop shall be nicked and tested to destruction.

TESTS AND INSPECTION.

(a) Two pieces shall be tested from each heat of steel. If either of these test pieces breaks, a third piece shall be tested. If two of the test pieces break without showing physical defect, all rails of the heat will be rejected absolutely. If two of the test pieces do not break, all rails of the heat will be accepted as No. 1 or No. 2 classification, according as the deflection is less or more, respectively, than the prescribed limit.

(b) If, however, any test piece broken under test "a", shows physical defect, the top rail from each ingot of that heat shall be rejected.

(c) Additional tests shall then be made of test pieces selected by the Inspector from the top end of any second rails of the same heat. If two out of three of these second test pieces break, the remainder of the rails of the heat will also be rejected. If two out of three of these second test pieces do not break, the remainder of the rails of the heat will be accepted, provided they conform to the other requirements of these specifications, as No. 1 or No. 2 classification, according as the deflection is less or more, respectively, than the prescribed limit.

(d) If any test piece, test "a", does not break, but when nicked and tested to destruction shows interior defect, the top rails from each ingot of that heat shall be rejected.

Le

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A

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B

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M

Form M.W. 403 (Old Form 2001-C).

Copy Ink.

A. B. & C. R. R. Co.

No._____

REPORT OF SHIPMENT.

of __________________ Process Rails ___________lbs. per yd ____________Section
(Open Hearth, Bessemer or Special.)

Manufactured by ______________________Steel Co. at __________________Works.

for ____

Consigned to ____

Order No. _______________ Date of Report ____________________19__

Quality No. ______________ Sheet No _____of____Sheets.

	Loaded on Cars.		Number of Rails of each Length.									Shipper's Weights. Pounds
	Initial	No.		33	30		27½		25		Total Rails	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14	For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures.											
8 15	9	9	5	5	5	5	5	5	5	5	6	8
16				Size of sheet required 8x10½ inches								
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
32												
	Totals											
	Total Weight Expressed in Gross Tons and Decimals.											

Total Tons of Order________Tons previously shipped_____ Balance due __________

INSTRUCTIONS

One copy of this report is to be sent to the Chief Engineer M of W., and two copies to the General Superintendent, one of which is for the Division Superintendent

Correct __________________________
Inspector.

Approved __________________________
Chief Inspector.
Engineer of Tests.

Form M. W. 404 (Old Form 2002-A.)

A. B. & C. R. R. Co.

No..................

.....................Division.........................Branch.

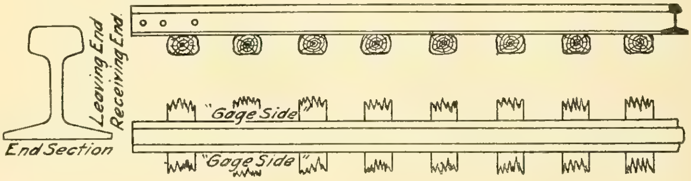
REPORT OF RAIL FAILURES IN MAIN TRACKS

Section No.......... Date of Report..........................191...

1 Weight per yard, New..............lbs
Re-rolled ....lbs.
2 Rail Section?........................
3 Brand on Rail? ("D" on back)........
4 Kind of Steel? ("E" on back)........
5 Heat No. on Rail? ("F"on back)......
6 Rail No. or Letter? ("F" on back)....
7 Original Length of Rail?.............
8 Month and Year Rail was Laid........
9 Location ....Feet ....of Mile Post ....
10 Which Track?........................
Which Rail? ....
11 On Curve or Straight Line?...........
11½ No. of Curve?.........................
12 Degree of Curve?....................
13 High or Low Rail, if on Curve?.......
14 Superelevation of Curve at "Break"?..
....
15 Was Rail "Broken"?.................
or "Defective"? ....
or Damaged? ....
(See "Description of Failures" on back)

16 Was Rail much or little worn?........
17 By whom discovered.................
18 Date and Time found?...............
19 Was Rail removed?..................
Date removed? ....
20 Exact gage of Track at "Break"?.....
21 Was "Break" over or between Ties?..
22 Was "Break" square or angular?.....
23 Distance between edges of Ties at "Break?" ....
24 Condition of Ties each side of "Break?"
....
25 Kind of Ties?........................
26 Were Tie Plates used?..............
Kind? ....
27 Condition of Line and Surface?......
28 Kind of Ballast?....................
29 Was Track properly ballasted?.......
30 Kind of material in roadbed under ballast? ....
31 Was Track well drained?............
32 Was Roadbed frozen?...............

33 Condition of weather? (Wet, dry, warm or cold, freezing or thawing).............
34 If "Broken," state cause of break, and describe any flaws found at point of break
....
35 If "Break" was at joint, state kind, number of holes, and whether it was full bolted or insulated...
36 Were any bolts at joint loose?......................If so, how many?............
37 Was accident or detention to trains caused by "Break"?..........................
If so, state circumstances...
38 If "Defective," describe kind and location of flaws or defects, and if possible, what caused them. (See "Description of Failures" on back)..................
....
....
39 Draw on Diagram lines of "Break," or partial fracture, such as long pieces from side of head and half-moon pieces from base, showing dimensions. Hollows in head should be shown on "End Section." Defects may also be indicated on Diagram. Mark distance from end to "Break." *If "Break" is nearest "Receiving End," draw pen through words "Leaving End;" if nearest "Leaving End," draw pen through words "Receiving End." (*Refers to track upon which the current of traffic is in one direction.) Indicate "Gage Side" on "Diagram" below, by drawing pen through words "Gage Side" on opposite side.



40 If "Damaged," describe nature and cause if known. (See "Description of Failures" on back)...

Correct: Approved:

............................Foreman. ....Supervisor.

Instructions, and Description of Failures, on Back.

Back of Form M. W. 404.

INSTRUCTIONS

A. The Foreman will send this Report to the Supervisor the same day the break is discovered, and in the case of a damaged or defective rail, the day it is taken out of the track.

B. The Supervisor will forward this Report direct to the Division Engineer.

C. The Division Engineer will have copies of this Report made immediately upon receipt and send a copy to the Chief Engineer M. of W.

D. The answer to 3 is in raised characters on the web of the rail.

E. The answer to 4 is "Bessemer" (B); "Open-Hearth" (O.H.); "Nickel" (N.); "Ferro-titanium (F.T.); "Chrome Nickel" (C.N.); or other method of manufacture or alloy.

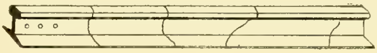
F. The answers to 5 and 6 are stamped into the metal on side of web—figures for 5 and a letter for 6.

G. Mile Post No. from { South / East } end of Division to be used.

DESCRIPTION OF RAIL FAILURES

When describing Failures of Rails, the following terms should be used.

1. **Broken Rail.** This term is to be confined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will come under this head.

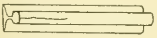


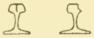
DEFECTIVE.

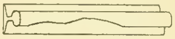
2. **Flow of Metal.** This term means a "Rolling Out" of the metal on top of the head towards its sides without there being any indication of a breaking down of the head structure, that is, the under side of the head is not distorted.

3. **Crushed Head.** This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.

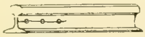
4. **Split Head.** This term includes rails split through or near the center line of the head, or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.



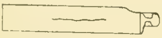


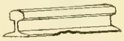


5. **Split Web.** This term is a longitudinal split along the axis of the web, generally starting from the end of rail through the bolt holes.



6. **Broken Base.** This term covers all breaks in base of rail and should be described and illustrated on sketches on front page.





7. **Damaged.** Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.

Form M. W. 405 (Old Form 2002-B.)

A. B. & C. R. R. Co.

Sheet No.......of......Sheets.

________________ Division.

Superintendent's Report of **Rail Failures** in Main Track for the Month of________________19_____

Report Number	DESCRIPTION OF RAIL									LOCATION OF RAIL					Date Laid		Day of Month Found	Time in Service		NATURE OF FAILURE							In Splice	Out of Splice	Line No.
	Weight per Yard	Type of Section	Marks on Rail						Lengths	Mile Post		Which Track	Curve or Tangent	Degree of Curve	Mo.	Year		Year	Mos.	Damaged	Broken	Flow of Metal	Crushed Head	Split Head	Split Web	Broken Base			
			Manufacturer	Rolled		Kind of Steel	Heat No.	Rail Letter		No.	Feet																		
				Mo.	Year																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
																													1
																													2
																													3
																													4
																													5
																													6
																													7
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																													11
																													12
																													13
																													14
																													15
																													16
																													17
																													18
																													19
																													20
																	Total Failures												

Grand Total of Failures for Month

Use following Marks for making entries in Columns:
In Column 4 use Car. for Carnegie. Ill. S. W. for Illinois, South Works.
Ill. G. for Illinois, Gary. Cam. for Cambria. Mar. for Maryland.
In Column 13 use E. B. P. for East Bound Passenger, etc.
" " 14 " T. for Tangent. I. C. for inner rail on Curve. O. C. for outer rail on Curve.
" " 21-22-23-24-25-26-27 use Fig. 1 to designate proper column.
Entries in Columns 21 to 27 should be repeated in Columns 28 or 29.

Instructions on back.

Correct.

.... Division Engineer

Approved.

.... Superintendent.

Back of Form M. W. 405.

INSTRUCTIONS

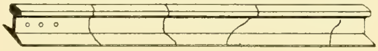
A. The Division Engineer will make out two copies of this report at the end of the month from the Section Foremen's Reports, and send one copy to the Chief Engineer M. of W. and one to the General Superintendent.

B. Mile Post No. from { South / East } end of Division to be used

DESCRIPTION OF RAIL FAILURES

When describing Failures of Rails, the following terms should be used:

1. **Broken Rail.** This term is to be confined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will come under this head.

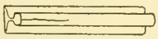


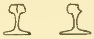
DEFECTIVE.

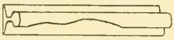
2. **Flow of Metal.** This term means a "Rolling Out" of the metal on top of the head towards its sides without there being any indication of a breaking down of the head structure, that is, the under side of the head is not distorted.

3. **Crushed Head.** This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.

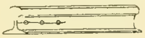
4. **Split Head.** This term includes rails split through or near the center line of the head, or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.



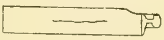


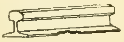


5. **Split Web.** This term is a longitudinal split along the axis of the web, generally starting from the end of rail through the bolt holes.



6. **Broken Base.** This term covers all breaks in base of rail and should be described and illustrated on sketches on front page.





7. **Damaged.** Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.

Form M.W. 406 (Old Form 2002-C).

A. B. & C. R. R. Co.

_______________________________Division.

Statement of Steel Rails existing in Main Tracks of_________________________________Division.

________________Main Track. December 31, 19___

Location.				Year Laid.	Brand.	Weight per Yard.	Type of Section.	Length of Feet in Track			
From		To						Laid Previous to 19	New Steel Laid 19	Steel Laid 19	Remarks.
M.P.	+ft.	M.P.	+ft.								
								1	2	3	4
For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures.											
4	5	4	5	3	12	4	5	8	7	7	16
Size of sheet required 8 inches wide.											

No. ft. 60 lb. Rail	No. Tons
" " 70 " "	" "
" " 85 " "	" "
" " 100 " "	" "

Column 3 to be used for any special rail, such as Re-rolled or Sawed and Re-drilled.

Correct:

To be made out and forwarded by the Engineer M. of W. to the Chief Engineer M. of W., as soon after the close of the year as possible.

Engineer M. of W.

Form M.W. 407 (Old Form 2003-A).

Copy Ink
Report No.

A. B. & C. R. R. Co.

Laboratory Report of Chemical and Physical Examination of Rail and Other Track Material.

Referred to in____

Laboratory No.___________Sample represents______________________________

Place and Date______________________19___

Chemical Analysis.											Physical Test.						
Location of Borings	C.	P	Mn	Si	S						Tensile S'gth Pounds Per	Elastic Limit Square Inch	Elongation Per Cent. in.	inches of Or. Lth.	Redn. of Area, % of Orig. Sec		
11	5	5	5	5	5	5	5	5	5	5	7	7	6	6	6	6	6

For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures

Size of sheet required, 8x10½ inches

Location of Borings

Remarks.

Approved

____
Chemist
Engineer of Tests.

Note The word "Borings" refers also to "Chippings" and other kinds of test fragments.

Enter under the head of "Tons Laid" all Kinds of Rail, with names of Manufacturers and Sections, which are in the Main Tracks, whether or not there have been failures.

Summary of Steel Rail Failures

______lb.______Sec.______Steel.

DIRECTIONS FOR FILLING IN THIS BLANK.

1. Enter on each sheet as many kinds of rail as the sheet will hold, and give the weight, section, kind of steel and manufacture of each group.
2. Foot up the columns of each group.
3. If failures are reported for years during which tons of "new rail laid" are not given, such failures should be footed separately from the failures of years during which tons of "new rail laid" are given.
4. Give the "gross tons over rail" for the year covered by this blank only, and enter it on the total line.
5. Give the number of failures (per 10,000 tons of rail laid) during the last year and the present year in whole numbers and tenths.

Lines	Year Laid	Tons of New Rail Laid Even Tons	Specified Chemical Analysis						Maximum Axle Load of Locomotives		Gross Tons over Rail Millions and Tenths
			C.	P	Mn	Si	S.		Freight Pounds	Passenger Pounds	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											

Note—Only statistics of Rails weighing over 70 lbs. per yard are required.
Rails broken or injured by wrecks, broken wheels or similar causes, are not to be included in this report.

Form M. W. 408 (Old Form 2004-A.)

A. B. & C. R. R. Co.

RAILROAD

for One Year Compared with same Period of Previous Year

Rolled by ________________ Steel Co.

Record for Period of One Year ending October 31, 19 ____

	Kind of Failure															Failures per 10,000 Tons of New Rail Laid		Lines
	Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total		Grand Total			
	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve		Last Year	Present Year	
%																		
No.																		1
%																		
No.																		2
%																		
No.																		3
%																		
No.																		4
%																		
No.																		5
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No.																		18
%																		
No.																		19
%																		
No.																		20
%																		
No.																		21

Form M.W. 409 (Old Form 2004-B).

______lb.______Section ________Steel. Rolled by____________ Steel Co.

Lines	Year Laid	Tons of New Rail Laid	Number of Rails which have failed each year below.														
1																	
2																	
3																	
4																	
5																	
6																	
7				For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures:													
8	5	7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
9							Size of sheet required, 8 x 21 inches.										
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
Totals																	

Form M.W. 409 (Old Form 2004-B).

A. B. & C. R. R. Co.

____________________________ Railroad

Summary of Steel Rail Failures for a Period of Years

Record for period of __________years ending_____________19___

	Kind of Failure														Grand Total	Failures per 10,000 tons new rail laid	Lines
	Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base		Total				
	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve	Tang.	Curve			
%	2																1
No.	2																
%	2																2
No.	2																
%	2																3
No.	2																
%	2																4
No.	2																
%	2																5
No.	2																
%	2																6
No.	2																
%	2																7
No.	2																
%	2																8
No.	5 2	5	5	5	5	5	5	5	5	5	5	5	5	5	7	5	
%	2																9
No.	2																
%	2																10
No.	2																
%	2																11
No.	2																
%	2																12
No.	2																
%	2																13
No.	2																
%	2																14
No.	2																
%	2																15
No.	2																
%	2																16
No.	2																
%	2																17
No.	2																
%	2																18
No.	2																
%	2																19
No.	2																

NOTE—Rails broken or injured by wrecks, broken wheels or similar causes, are not to be included in this report.

Form M.W. 410 (Old Form 2004-C.)

A. B. & C. R. R. Co.

Sheet No.________ of ________ Sheets.

________________________________Division

Comparative Number Of Failures of Steel Rails of Different Section or Pattern Rolled by Different Steel Companies.

Record for Period of ____________________ending __________________19_____

Steel Company and Mill where Rail was Rolled	Rail weight per yard, lbs.	Rail Section or Pattern	No. of Tons of Rail laid in Track	Kind of Failure														Grand Total	No. of Failures per 10,000 Tons of New Rail Laid
				Broken		Flow of Metal		Crushed Head		Split Head		Split Web.		Broken Base		Total			
				Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve		
			4	2 2															
			4	2 2															
			4	2 2															
			4	2 2															
			4	2 2															
10	4	5	7 4	2 2 4	4	4	4	5	4	5	4	4	4	4	4	5	5	7	5
			4	2 2															
			4	2 2															
			4	2 2															
			4	2 2															
			4	2 2															
			4	2 2															
			4	2 2															

For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures:

Size of sheet required, 8x10½ inches.

Note: The percentages which the record figures are of the total are to be put above the record figures in the several columns under "Kind of Failures."

Form M.W. 411 (Old Form 2004-D).

A. B. & C. R. R. Co.

________________ Division

Position in Ingot of Steel Rails which Failed for Period of ________ ending ________ 19___

________________ Type of Rail Section

Sheet No. ______
of ______ Sheets

Kind of Failure	____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel							
	lb.								lb.								lb.								lb							
	A	B	C	D	E	F	Un-known	Total	A	B	C	D	E	F	Un-known	Total	A	B	C	D	E	F	Un-known	Total	A	B	C	D	E	F	Un-known	Total
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel							
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel								____ Steel Co. ______ Mill ______ Steel							
Broken																																
Flow of Metal						For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures:																										
Crushed Head	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5
Split Head													Size of sheet required, 8x15$\frac{8}{10}$ inches.																			
Split Web																																
Broken Base																																
Totals																																

Note The letters A, B, C, etc., denote the position of the Rail in the ingot, "A" being the top rail, "B" the second, etc
The percentages which the record figures are of the total are to be put above the record figures in the columns under A, B, C, etc.,
Only Statistics of Rail weighing over 70 lbs. per yard are required.

(Cover Page for Forms M. W. 408, 409, 410, 411.)

Form M.W. 412 (Old Form 2004-E).

A. B. & C. R. R. Co.

____________________Division

Numerical Record and Position in the Ingot of Steel Rails which have Failed in Service.

on____________________

Year____________ to Year 19____

Office of CHIEF ENGINEER M. of W.
(or other officer)

Form M.W. 413 (Old Form 2005-A).

A ____________ shown in Red B ____________ shown in Yellow

Summary

Month and Year												
Kind of Rail	A	B	A	B	A	B	A	B	A	B	A	B
Total sq. in. abraded												
Ave. sq. in. abraded per Section												
Percentage of Area abraded to total Area of Head												

A. B. & C. R. R. Co.

____________________________ Division

Location Diagram

of

____________________________________ Rails

Laid in 19 ____________ Removed in 19 ________

Between ________________ and ________________

Office of Chief Engineer M. of W. ______________ R. R.

Scale 1 in.=1 mile Date ____________________

Form M.W. 414 (Old Form 2005-B).

A ______________ shown in Red B ______________ shown in Yellow

Summary

Month and Year												
Kind of Rail	A	B	A	B	A	B	A	B	A	B	A	B
Total sq. in. abraded Ave. sq. in. abraded per Section Percentage of Area abraded to total Area of Head												

A. B. & C. R. R. Co.

______________________________ Division

Location Diagram

of

____________________________________ Rails

Laid in 19 ____________ Removed in 19 ________________

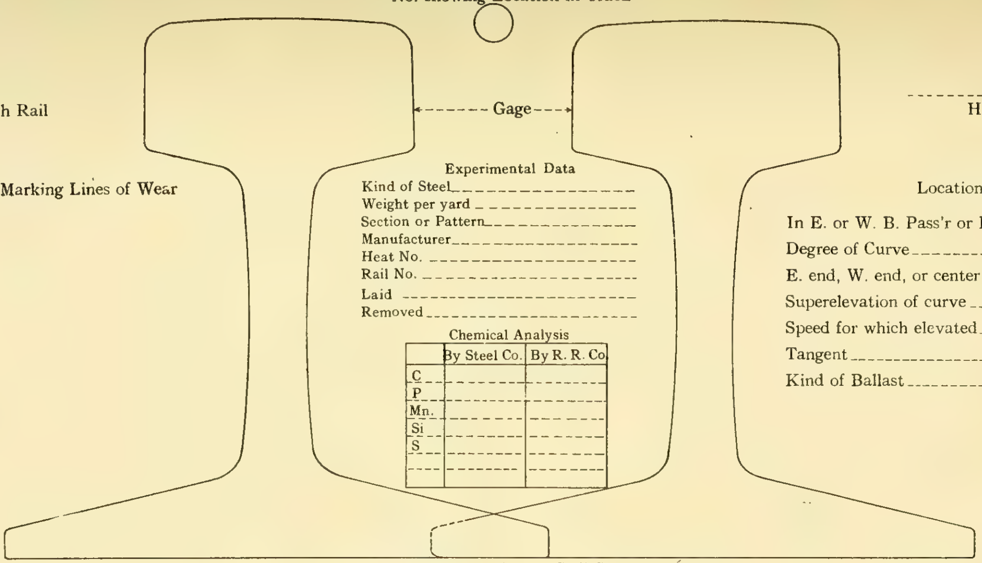
Between ________________ and ______________________

Office of Chief Engineer M. of W. ______________ R. R.

Scale 2 in.=1 mile Date ______________________

Form M.W. 415 (Old Form 2005-C).

No. showing Location in Track



Low or South Rail

Scheme of Marking Lines of Wear

High or North Rail

Experimental Data

Kind of Steel________________
Weight per yard ______________
Section or Pattern____________
Manufacturer_________________
Heat No. ____________________
Rail No. _____________________
Laid ________________________
Removed _____________________

Chemical Analysis

	By Steel Co.	By R. R. Co.
C		
P		
Mn.		
Si		
S		

Location Data

In E. or W. B. Pass'r or Frt. ________________
Degree of Curve ____________________________
E. end, W. end, or center of curve ______________
Superelevation of curve _____________________
Speed for which elevated ____________________
Tangent ___________________________________
Kind of Ballast ______________________________

Measurements taken at Rail Center

Measurements of Area Abraded

Date of Measurement	Sq. in. Abraded: Low Rail: Area Abraded	Sq. in. Abraded: Low Rail: Diff.	Sq. in. Abraded: High Rail: Area Abraded	Sq. in. Abraded: High Rail: Diff.

________________________Div.
Diagram Showing Lines of Wear
of
____________________________Rail
Laid in 19____________Removed in 19____________
Between ________________and ________________
Office of Chief Engineer M. of W. ________________R. R.
Scale, Full Size. ______________ Date ____________

Form M.W. 416 (Old Form 2005-D).

A. B. & C. R. R. Co.

______________________________ Division

Record of Comparative Wear of Special Rail

Date of Report ______________________________ 19_____

Special Rail													Chemical Composition of Rail of Section with which Special Rail was Compared							Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																							Special		Comparative	
						C	P	Mn	Si	S			C	P	Mn	Si	S						Sq. in. abraded	% of area of Head	Sq. in abraded	% of area of Head
			For filling in with typewriter columns should be spaced in tenths of an inch as shown by the figures:																							
12	*14*	*6*	*5*	*6*	*10*	*4*	*4*	*5*	*4*	*4*	*4*	*4*	*4*	*4*	*5*	*4*	*4*	*4*	*4*	*6*	*6*	*6*	*5*	*5*	*5*	*5*
								Size of sheet required, 8x15$\frac{8}{10}$ inches.																		

Note: Only Statistics of Rails weighing over 70 lbs. per yard are required.

(Cover Page for Forms M.W. 413, 414, 415, 416.)

Form M.W. 417 (Old Form 2005-E).

A. B. & C. R. R. Co.

____________________Division

RAIL SECTIONS

Showing Progressive Wear
of

__________and__________Steel Rails.

Laid____________________ Removed____________________

Office of CHIEF ENGINEER M. of W.
(or other officer)

SPECIFICATIONS AND INSTRUCTIONS FOR USE OF FORMS M. W. 401 to M. W. 418.

Size of sheet shown on each form.

GROUP I—REPORTS OF RAIL INSPECTION AND SHIPMENT AT THE MILL.

This set of forms is for the use of the railroad company's inspector at the mills where the rail is rolled, and gives all the information necessary to inform the purchaser that his order has been manufactured in accordance with the specifications and shipped.

M. W. 401—Report of Chemical and Physical Examination:

This blank is filled out from the mill records under the supervision of the Inspector, and gives the chemical contents taken from the ladle analysis and the result of the drop test.

M. W. 402—Certificate of Inspection:

This is the Inspector's written statement that the material which he has witnessed rolled has been turned out strictly in accordance with the specifications and the order of the railway company.

M. W. 403—Report of Shipment:

This blank is used for reporting the number and length of rail shipped in each car from the works and, when properly checked by the Receiving Officer, it furnishes the basis for payment of the bill.

M. W. 418—Results of Drop Tests and Surface Inspection of Rails Rolled:

This form is intended for tabulating the results of drop tests and surface inspection of rails rolled.

GROUP II—REPORTS FROM DIVISION OFFICERS.

This group contains all the regular reports which come from the division officers concerning the rails which have been put in service in track.

M. W. 404—Report of Rail Failures in Main Tracks:

This is the basic report of all rail failures and is sent by the Track Foreman to the Supervisor and by the latter transmitted to the Division Engineer. It contains a classification of rail failures which is used in the tabulations employed in the following blanks.

M. W. 405—Superintendent's Monthly Report of Rail Failures in Main Tracks:

On this blank the Division Engineer informs the Superintendent of the total number of rail failures for the month tabulated from the Track Foreman's report, and other officers who are interested, such as the Chief Engineer, Chief Engineer of Maintenance of Way or General Superintendent, are furnished with copies. In cases where a copy of the Track Forman's Report is sent to the Chief Engineer or Chief Engineer of Maintenance of Way, the monthly report serves as a check on the receipt of all individual rail reports.

M. W. 406—Annual Statement of Steel Rails Existing in Main Tracks:

This is an annual report sent by the Division Engineer to the Chief Engineer or Chief Engineer of Maintenance of Way for the permanent record of the company, to show the different kinds of steel in the main tracks at the end of the year. This may be used in conjunction with the rail chart, or take its place altogether, because the rail chart may not be in convenient form for a permanent record which may be referred to, after many years, for information concerning the kind of rail in use at a stated period.

GROUP III—LABORATORY EXAMINATION OF SPECIAL RAILS.

M. W. 407:

This group is, at present, represented by this single form. It is used for making check analyses against the mill analyses and for reporting the result of chemical analysis and physical test of special rail or other test pieces which may be sent to the laboratory, from time to time, for examination.

GROUP IV—COMPILATION OF RESULTS FOR STUDY.

This group exhibits the different ways for compiling quantitative statistics of rail failures.

M. W. 408—Summary of Steel Rail Failures for One Year Compared With the Same Period of Previous Year:

This blank is intended for compiling the information relative to rail failures for a period of six months, it can also be used for other periods if found desirable. The failures are reduced to percentage of tons of rails laid in preference to the number of rail per thousand tons of rail laid, for the reason that the latter does not take care of different lengths of rail.

The columns for "specified chemical analysis" are intended for recording the analyses of the particular lot of rail as given in the specification, and is inserted in this blank in order to give an idea as to whether the rail is high or low in carbon, or high or low in phosphorus, etc.

M. W. 409—Summary of Steel Rail Failures for a Period of Years:

This blank has been provided on which the results from M. W. 408 will be recorded at the end of the year, thus making a continuous record.

M. W. 410—Comparative Number of Failures of Steel Rails of Different Section or Pattern, Rolled by Different Steel Companies:

In order to compare the product of different mills, and also to compare different weights per yard and different sections together, this blank has been provided. It contains the totals taken from M. W. 408 or M. W. 409, as desired.

M. W. 411—Position in Ingot of Steel Rails Which Failed:

This is intended to furnish data on the number and character of rail failures according to the original position in the ingot held by the rail in question.

M. W. 412:

The information in this group should be bound together in one book; this cover has been provided for convenience and neatness.

GROUP V—PROGRESSIVE WEAR OF SPECIAL RAIL UNDER OBSERVATION.

In order to keep track of special rail, from time to time, and determine the value of the results being given, it is necessary to have a systematic plan of procedure for examination and records. This group is furnished for that purpose, and is provided with a cover, as in the case of the previous group.

M. W. 413—Location Diagram:

This blank is on a scale one in. equals one mile, and is intended for diagrams showing the location in different places of the same kind of rail under trial.

M. W. 414—Location Diagram:

This blank is similar to M. W. 413, except that it is on a scale of two in. equals one mile, and is intended to show the location of a particular portion of the rail given in M. W. 413. It is made on a larger scale so as to locate the points of measurement. A place is provided on each blank for the summary of the wear or area abraded in percentage of total area of head.

M. W. 415—Diagram Showing Lines of Wear:

The measurement of rail section at a specified point is shown on this blank and its position on M. W. 414 is given by the number in the circle in the center of the blank at the top. All statistical information of interest and importance is given on the blank.

M. W. 416—Record of Comparative Wear of Special Rail:

This blank is intended for compiling the information given in the previous ones, so as to give a general summary of the results.

M. W. 417:

The information in this group should be bound together in one book; this cover has been provided for convenience and neatness.

*REPORT OF STUDY OF AN INDIVIDUAL RAIL.

(1) A complete report of the study of an individual rail should consist of:

(a) Copy of the Track Foreman's report on Form M. W. 404, after being checked by an engineer.

(b) Results of chemical analysis and physical test on Form M. W. 407.

(c) Photographs of the defect or fracture and micro-photographs of the interior structure.

(d) A complete written analysis or deduction from the study of the above information.

†SPECIFICATIONS FOR DROP TESTING MACHINE.

A drop testing machine conforming essentially to the manufacturers' plans and specifications and in general accord with the following requirements will give satisfactory results:

1. The machine shall be arranged to allow a 2,000-lb. tup to fall freely at least 25 ft. on the center of a rail resting on supports that can be adjusted to spans varying from 3 ft. to 4 ft. 6 in.

2. The anvil shall be a solid casting, weighing, with the attachments that move with it, 20,000 lbs. It shall be free to move vertically independently of the lead columns and shall be supported on 20 springs known as the standard "C" spring, without center coil, as employed by the Master Car Builders' Association (their Fig. 5614). This spring has a free length of eight and one-quarter (8¼) in., an outside diameter of five and seven-sixteenths ($5\frac{7}{16}$) in., and is made from a bar having a diameter of one and three-sixteenths ($1\frac{3}{16}$) in. These springs are to be arranged in groups of five at each corner of the anvil and are to be held in place by hubs raised on the top of the base plate and by circular pockets on the underside of the anvil. Anvil to be guided in its vertical movement by removable finished wearing strips, these wearing strips to be suitably attached to the finished edges of the column base.

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*Adopted, Vol. 10, Part 1, 1909, pp. 340, 341, 348, 349, 353, 375, 393, 394, 395, 396.

† Adopted, Vol. 10, Part 1, 1909, pp. 369-373, 375, 395, 396; Vol. 11, Part 1, 1910, pp. 240, 252, 562.

3. The base plate shall be of cast-iron or cast steel eight (8) in. thick in the area covered by the anvil. It shall be firmly secured to the substructure by four bolts two (2) in. in diameter.

4. The substructure shall consist of a timber grillage resting on a masonry foundation. The grillage shall project nine (9) in. beyond the ends of the base plate, and clear the columns at the side. It shall consist of one course of twelve by twelve (12x12) in. sound oak or Southern yellow pine, preferably creosoted, laid close and well bolted together. The masonry, preferably concrete, shall be not less than five (5) ft. deep below the grillage and be suitably supported on the subsoil.

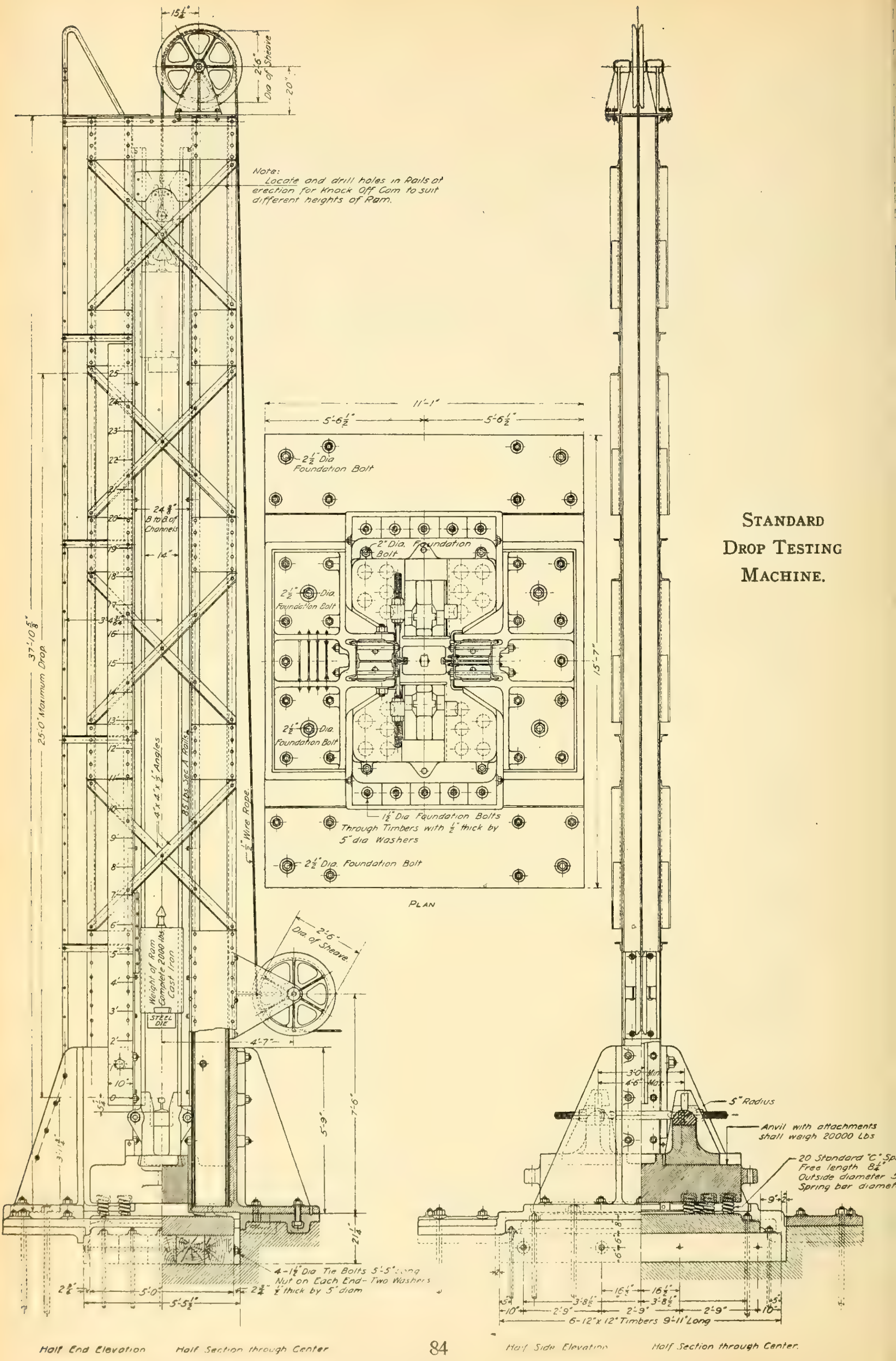
5. The pedestals for supporting the test rail shall be substantial castings, and the surface of the anvil between these pedestals shall be formed to receive a wooden block to absorb shock under broken test pieces. The rail supports shall be removable pieces of steel, securely held in the pedestals, having an upper cylindrical bearing surface, with a radius of five (5) in. The pedestals shall be adjustable to spans varying from three (3) ft. minimum to four (4) ft. six (6) in. maximum between centers. They shall be securely held together, and so fixed to the anvil as to insure that the center of span shall always coincide with the center between leads.

6. The leads shall be firmly connected to the column base and well braced. They shall be long enough to provide the prescribed free fall of the tup. They shall be provided with a convenient ladder and a plainly marked gage, divided into one-foot intervals. The zero of this gage shall be five and one-quarter (5¼) in. above the top of the rail support, and the specified height of drop shall be measured from this zero irrespective of the height of rail being tested. One of the guides shall have a removable section six (6) ft. long at the bottom, so that the tup or tripping block can be readily removed.

7. The tup shall weigh, with the accessories that drop with it, 2,000 lbs. The striking die shall be steel, having a cylindrical striking face, with radius five (5) in. and a length of twelve (12) in. The guide grooves shall have finished surfaces. The tripping head shall allow a grip of the tongs that will release at the exact height for which the tripping device is set, and that will be safe from accidental release while the test piece is being shifted.

8. The tongs and tripping device shall be arranged to release the tup automatically only; no manual releasing will be allowed. The tripping device shall be easily adjusted at one-foot intervals.

STANDARD DROP TESTING MACHINE.


15¼"
2'-6" Dia of Sheave
20"
Note: Locate and drill holes in Rails at erection for Knock Off Cam to suit different heights of Ram.
37'-10⅝"
25'-0" Maximum Drop
24⅜" B to B of Channels
14"
3'-4¾"
4"x4"x½" Angles
85 lbs Sec A Rails
½" Wire Rope
Weight of Ram Complete 2000 lbs Cast Iron
STEEL DIE
2'-6" Dia. of Sheave
4'-7"
5'-9"
7'-6"
2'1¼"
3'-1¼"
5½
4-1½" Dia Tie Bolts 5'-5" Long Nut on Each End - Two Washers ½" thick by 5" diam
2⅛"
5'-0"
5'-5½"
2¼"
11'-1"
5'-6½"
5'-6½"
15'-7"
2½" Dia Foundation Bolt
2" Dia. Foundation Bolt
2½" Dia. Foundation Bolt
2½" Dia. Foundation Bolt
1½" Dia Foundation Bolts Through Timbers with ½" thick by 5" dia Washers
2½" Dia. Foundation Bolt
PLAN
3'-0" Min
4'-6" Max
5" Radius
Anvil with attachments shall weigh 20000 Lbs
20 Standard "C" Sp
Free length 8¼"
Outside diameter
Spring bar diamet
9"
6'-6⅜"
16½"
16½"
3'-8½"
3'-8½"
10"
2'-9"
2'-9"
2'-9"
10"
6-12"x12" Timbers 9'-11" Long

Half End Elevation *Half Section through Center* *Half Side Elevation* *Half Section through Center.*

COMMITTEE V.

TRACK.

*DEFINITIONS.

ALINEMENT.—The horizontal location of a railway with reference to curves and tangents.

AUXILIARY FASTENINGS.—Nutlocks, tie-plates, rail braces, and anti-creeping devices.

CURVE.—A change in direction by means of one or more radii.

CURVE, COMPOUND.—A change consisting of two or more simple curves of different radii, all in the same direction, joining one another at points with common tangent.

CURVE, DEGREE OF.—The angle subtended by a 100-ft. chord.

CURVE, EASEMENT.—A curve of regular varying radii connecting a tangent to a simple curve, or connecting two simple curves.

CURVE, REVERSE.—Two curves in opposite direction in a continuous line joining at a common tangent point.

CURVE, SIMPLE.—A change in direction by means of a single radius.

CURVE, VERTICAL.—A curve used to connect intersecting grade-lines.

ELEVATION (as applied to curves).—The amount which the outer rail is raised above the inner rail.

FASTENINGS.—Splices, bolts and spikes.

FROG NUMBER.—One-half the co-tangent of one-half the frog angle.

GAGE (OF TRACK).—The distance between the heads of the rails measured at right angles thereto at a point ⅝-in. below the top of the rail.

GAGE, STANDARD.—The gage of 4 ft. 8½ in.

LEVEL.—The condition of the track in which the elevation of the rails transversely is equal.

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* Adopted, Vol. 5, 1904, pp. 527, 535, 541-560; Vol. 6, 1905, pp. 748, 749, 759-761; Vol. 10, 1909, pp. 400, 461-463; Vol. 11, Part 2, 1910, pp. 942, 955.

LINE.—The condition of the track in regard to uniformity in direction over short distances on tangents, or uniformity in variation in direction over short distances on curves.

SURFACE.—The condition of the track as to vertical evenness or smoothness over short distances.

TANGENT.—Straight track.

TRACK.—Ties, rails and fastenings; with all parts in their proper relative positions.

*TEMPERATURE EXPANSION FOR LAYING RAILS.

The allowance that should be made for expansion for 33-ft. rails is shown in the following table.

The temperature should be taken on the rail, and the openings between the rail ends should be as follows:

TEMPERATURE. (Fahrenheit.)	ALLOWANCE.
—20° to 0°	5/16 in.
0° to 25°	1/4 in.
25° to 50°	3/16 in.
50° to 75°	1/8 in.
75° to 100°	1/16 in.

Over 100 degrees rails should be laid close without bumping.

†STANDARD RAIL JOINT.

A standard rail joint should fulfill the following general requirements:

(1) It should connect the rails into a uniform continuous girder.

(2) It should be strong enough to resist deformation or taking permanent set.

(3) It should prevent deflection or vertical movement of the ends of the rails and permit movement lengthwise for expansion.

(4) It should be as simple and of as few parts as possible to be effective.

(5) Its cost should not be prohibitive.

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[*] Adopted, Vol. 2, 1901, pp. 190, 122.

[†] Adopted, Vol. 7, 1906, pp. 655, 657.

*REQUISITES FOR SWITCHSTANDS.

(1) There should be no lost motion in parts.

(2) Stands should have an adjustable throw on the foot.

(3) The operating lever of ground stands should work parallel with the track.

(4) Throwing apparatus should be so arranged that when the switch is set for movement of a train, it will be thrown to an extreme position and the throwing rod be locked independent of the latch on the stand lever.

(5) The stand should be snowproof.

(6) The connection between the throwing rod and the stand should be so arranged that it will be impossible to separate the throwing rod from the stand when the stand is set up in working position.

(7) The stand should be so arranged that it can be easily inspected.

(8) The target should not show clear signal for main track movements unless the points are up snug against the stock rail.

(9) The targets shall conform to drawing No. —.

†DESIGN OF TRACK FASTENINGS.

Where there is material leakage from track circuits, track fastenings should be so designed as to prevent contact between the metal and the ballast.

‡FROG BLOCKING.

The heel of a frog should be made with a steel filler block, to fit the section of rail, securely bolted, and with the outer end of filler planed off ⅜-in. below top of rail to act as a riser for the outer edge of worn treads.

The wings and throats of all frogs should be blocked with metal or wood blocking, shaped to fit rail sections, to give 1½-in. flange clearance, and be securely bolted to frog.

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* Adopted, Vol. 5, 1904, pp. 525, 526, 571; Vol. 6, 1905, pp. 757, 758, 760.
† Adopted, Vol. 11, Part 2, 1910, pp. 935, 942, 944.
‡ Adopted, Vol. 11, Part 2, 1910, pp. 939, 942, 946.

* TURNOUTS.

FORMULAS.

Given—	Required—
$G =$ Gage of track.	$a =$ Switch angle.
$N =$ Frog number.	$L =$ Lead distance measured along center line of main track from point of switch to point of frog.
$F =$ Frog angle.	$R =$ Radius of center line of lead curve.
$W =$ Length of wing rail.	$D =$ Degree of lead curve.
$S =$ Length of switch rail.	$\overline{CE_1ED} =$ Arc of outer rail of lead curve.
$H =$ Heel distance.	$\overline{Z_1D_1} =$ Length of straight rail in lead.
	$Y =$ Perpendicular offset from any point on the curved lead rail to the main track rail.
	$X =$ Distance from foot of such offset to point of switch rail.

In the accompanying figure, A, Z, V, B and Z_1, D_1, P, represent points on the gage sides of the main track rails. C, E_1, E and D represent points on outer rail of lead curve.

$G =$ Gage.
$P =$ Theoretical point of frog.
$D =$ Toe of frog.
$\overline{PD} = W =$ Length of wing rail.
$\measuredangle Z_1PD = \measuredangle Z_1PI = F =$ Frog angle.
$A =$ Point of switch rail.
$C =$ Heel of switch rail.
$\overline{AC} = S =$ Length of switch rail.
$Z =$ Foot of perpendicular from gage side of switch rail at heel upon gage side of main track rail.
$\overline{CZ} = H =$ Heel distance.
$\measuredangle CAZ = \measuredangle UAB = a =$ Switch angle.
$O =$ Center of lead curve.
$R =$ Radius of lead curve.
$D =$ Degree of lead curve.
$\overline{CD} =$ Long chord of lead curve.

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* Adopted, Vol. 10, 1909, Part 1, pp. 402-407, 451-461; Vol. 11, Part 2, 1910, pp. 940, 941, 952-954.

$\overline{CE_1ED}$ = Arc of curved or outer rail of lead curve tangent to heel of switch rail at C and to toe of frog at D.

$\overline{OC} = \overline{OE_1} = \overline{OE} = \overline{OD} = (R + \frac{G}{2})$ = Radius of outer rail of lead curve.

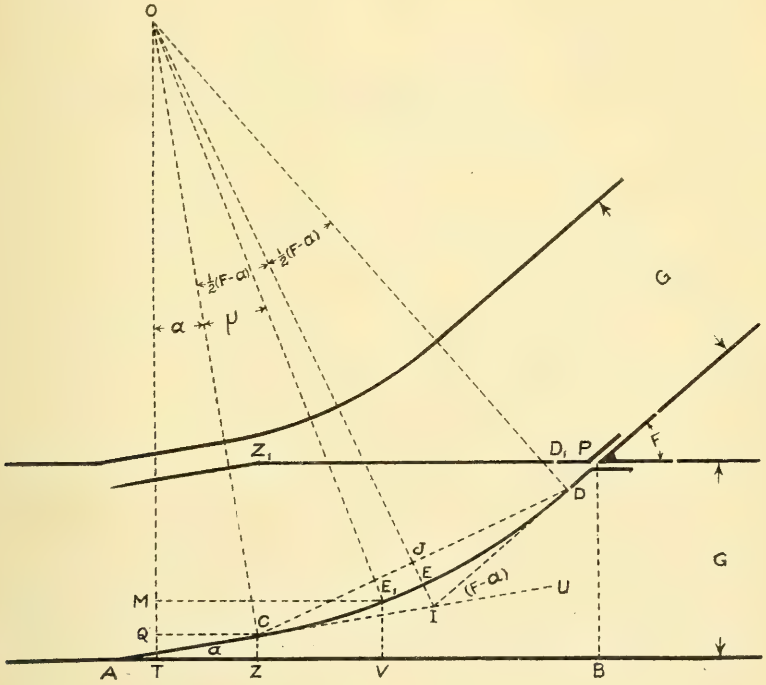
Extend $\overline{PD}$ and $\overline{AC}$ to intersect at I, then $\overline{DI} = \overline{CI}$ = Tangent distance of lead curve.

$\sphericalangle DIU = \sphericalangle DOC = (F - a)$ = Angle of intersection = Center angle of lead curve.

$\sphericalangle DCI = \sphericalangle DOI = \sphericalangle IOC = \frac{1}{2}(F - a)$. $(\sphericalangle DCI + \sphericalangle CAZ) = \frac{1}{2}(F + a)$ = Angle of long chord $\overline{CD}$ with $\overline{AB}$.

B = Foot of perpendicular from point of frog upon gage side of opposite main track rail.

$\overline{AB}$ = Lead.



$$\text{Sin } \sphericalangle CAZ = \frac{\overline{CZ}}{\overline{AC}} = \sin a = \frac{H}{S} \therefore a = \sin^{-1}\frac{H}{S} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

To correct for actual thickness of point of switch rail, deduct the thickness of the point from H before dividing by S.

The sum of the projections of $\overline{AC}$, $\overline{CD}$, and $\overline{DP}$ upon $\overline{PB}$ is equal to $\overline{PB}$.

$(\overline{AC}\cdot \sin\sphericalangle CAZ)+[\overline{CD}\cdot \sin(\sphericalangle DCI+\sphericalangle CAZ)]+(\overline{DP}\cdot\sphericalangle Z_1PD)=\overline{PB}$

Substituting the values of the given quantities and solving for $\overline{CD}$.

$$\overline{CD}=\frac{G-(W\cdot\sin F+S\cdot\sin a)}{\sin\frac{1}{2}(F+a)}\ldots\ldots\ldots\ldots(2)$$

The sum of the projections $\overline{AC}$, $\overline{CD}$, and $\overline{DP}$ upon $\overline{AB}=\overline{AB}$.

$\overline{AB}=(\overline{AC}\cdot\cos\sphericalangle CAZ)+[\overline{CD}\cdot\cos(\sphericalangle DCI+\sphericalangle CAZ)]+(\overline{DP}\cdot\cos\sphericalangle Z_1PD)$

$L=S\cdot\cos a+\overline{CD}\cdot\cos\frac{1}{2}(F+a)+W\cdot\cos F\ldots\ldots\ldots\ldots(3)$

Substituting in (3) the value for $\overline{CD}$ given in (2) and simplifying,

$$L=(S-W)\frac{\sin\frac{1}{2}(F-a)}{\sin\frac{1}{2}(F+a)}+G\cdot\cot\frac{1}{2}(F+a)\ldots\ldots\ldots\ldots(4)$$

(a) To correct for the actual thickness of the point of switch rail, deduct the thickness of the point from G before solving (4).

(b) To correct for the actual thickness of the point of frog. After solving (4), increase L by the product obtained by multiplying the thickness of the frog point (expressed in decimals of a foot) by the frog number.

$$\overline{OD}=\frac{\overline{JD}}{\sin\sphericalangle DOJ}=\frac{\overline{CD}}{2\cdot\sin\frac{1}{2}(F-a)}\ldots\ldots\ldots\ldots(5)$$

Substituting for $\overline{CD}$ in (5) the value given in (2), and solving for R.

$$R=\frac{G-H-W\cdot\sin F}{2\cdot\sin\frac{1}{2}(F-a)\cdot\sin\frac{1}{2}(F+a)}-\frac{G}{2}\ldots\ldots\ldots\ldots(6)$$

or the value of R may be expressed as follows:

$$R=\frac{G-H-W\cdot\sin F}{\cos a-\cos F}-\frac{G}{2}\ldots\ldots\ldots\ldots(7)$$

$$D=2\cdot\sin^{-1}\frac{50}{R}\ldots\ldots\ldots\ldots(8)$$

$$\overline{CE_1\ ED}=\frac{2\cdot\pi\cdot\left(R+\frac{G}{2}\right)\cdot(F-a)}{360}=0.017453\left(R+\frac{G}{2}\right)\cdot(F-a)\ldots(9)$$

In (9), $(F-a)$ is expressed in degrees and decimals of a degree.

$\overline{Z_1D_1}=L-(W+S)\ldots\ldots\ldots\ldots(10)$

Let E_1 be any point on the gage side of the outer rail of the lead curve. Draw the radius $\overline{OE}$. Drop a perpendicular from O upon the gage side of the main track rail at T. From O draw the radius $\overline{OC}$ perpendicular to the switch rail at its heel. $\measuredangle COT = a$. From E_1 let fall a perpendicular upon the gage side of the main track rail at V and upon $\overline{OT}$ at M. Let fall a perpendicular from C upon the gage side of the main track rail at Z and upon $\overline{OT}$ at Q. Let $\measuredangle E_1OC = \mu$ and let A = point of switch rail.

$$Y = \overline{E_1V} = \overline{MT} = (\overline{OQ} - \overline{OM} + \overline{QT}) = \overline{OQ} - \overline{OM} + \overline{CZ}$$

$$Y = \left[H + \left(R + \frac{G}{2}\right) \cdot \cos a\right] - \left(R + \frac{G}{2}\right) \cdot \cos(\mu + a) \dots\dots\dots\dots (11)$$

$$X = (\overline{AT} + \overline{TV}) = (\overline{AZ} - \overline{TZ}) + \overline{TV} = \overline{AZ} - \overline{QC} + \overline{ME_1}$$

$$X = \left[S - \left(R + \frac{G}{2}\right) \cdot \sin a\right] + \left(R + \frac{G}{2}\right) \cdot \sin(\mu + a) \dots\dots\dots\dots (12)$$

SUMMARY.

$$a = \sin^{-1} \cdot \frac{H}{S} \dots\dots\dots\dots (1)$$

$$L = (S - W) \frac{\sin \frac{1}{2}(F - a)}{\sin \frac{1}{2}(F + a)} + G \cdot \cot \tfrac{1}{2}(F + a) \dots\dots\dots\dots (4)$$

$$R = \frac{G - H - W \cdot \sin F}{2 \cdot \sin \frac{1}{2}(F - a) \cdot \sin \frac{1}{2}(F + a)} - \frac{G}{2} \dots\dots\dots\dots (6)$$

$$R = \frac{G - H - W \cdot \sin F}{\cos a - \cos F} - \frac{G}{2} \dots\dots\dots\dots (7)$$

$$D = 2 \cdot \sin^{-1} \frac{50}{R} \dots\dots\dots\dots (8)$$

$$\overline{CE_1ED} = 0.017453 \cdot \left(R + \frac{G}{2}\right) \cdot (F - a) \dots\dots\dots\dots (9)$$

$$\overline{Z_1D_1} = L + (W - S) \dots\dots\dots\dots (10)$$

$$Y = \left[H + \left(R + \frac{G}{2}\right) \cdot \cos a\right] - \left(R + \frac{G}{2}\right) \cdot \cos(\mu + a) \dots\dots\dots\dots (11)$$

$$X = \left[S - \left(R + \frac{G}{2}\right) \cdot \sin a\right] + \left(R + \frac{G}{2}\right) \cdot \sin(\mu + a) \dots\dots\dots\dots (12)$$

To correct (1) and (4) for the actual thickness of point of switch rail, deduct the thickness of the point from H and G before solving for a and L. To correct (4) for the actual thickness of the frog point: After solving (4), increase L by the product of $N.t$, where N = frog number and t = actual thickness of frog point expressed in decimals of a foot. In (9), $(F - a)$ is expressed in degrees and decimals of a degree. In (11) and (12) it is recommended that the value of X and Y be obtained for at least three values of μ, namely, $\mu = \frac{1}{4}(F - a)$, $\mu = \frac{1}{2}(F - a)$, $\mu = \frac{3}{4}(F - a)$.

In all cases Gage is considered 4 ft. 8½ in.

TABLE OF THEORETICAL AND PRACTICAL SWITCH LEADS.

PROPERTIES OF FROGS. Thickness of All Frog Points 0½"												Properties of Switches. For All Switches Thickness of Point=0¼" and Heel Distance =H=6¼"					THEORETICAL LEADS						
N=Frog Number.	F=Frog Angle.			W=Length Point to Toe.		K=Length Point to Heel.		Total Length.		Spread at Toe.	Spread at Heel.	S=Length of Switch Rail.		a=Switch Angle.			R=Radius of Center Line.	D=Degree of Lead Curve.			Distance Point of Switch Rail to Theoretical Point of Frog.	Closure Straight Rail.	Closure Curved Rail.
I	II			III		IV		V		VI	VII	VIII		IX			X	XI			XII	XIII	XIV
	Deg.	Min.	Sec.	Ft.	In.	Ft.	In.	Ft.	In.	Feet	Feet	Ft.	In.	Deg.	Min.	Sec.	Feet	Deg.	Min.	Sec.	Feet	Feet	Feet
4	14	15	00	3	2	5	4	8	6	0 79	1 32	11	0	2	36	19	112.26	52	53	56	37.05	22.88	23.29
5	11	25	16	3	7	6	5	10	0	0 71	1.28	11	0	2	36	19	183.22	31	40	24	42.77	28.19	28.55
6	9	31	38	4	0	7	0	11	0	0.66	1.16	11	0	2	36	19	273.95	21	01	58	48.11	33.11	33.38
7	8	10	16	4	5	8	1	12	6	0.63	1.15	16	6	1	44	11	364.88	15	47	19	61.94	41.02	41.24
8	7	09	10	4	9	8	9	13	6	0.59	1.09	16	6	1	44	11	488.71	11	44	40	67.47	46.22	46.42
9	6	21	35	6	0	10	0	16	0	0.67	1.11	16	6	1	44	11	616.27	9	18	27	72.24	49.74	49.92
9½	6	01	32	6	0	10	0	16	0	0.63	1.05	16	6	1	44	11	699.97	8	11	33	74.90	52.40	52.58
10	5	43	29	6	0	10	6	16	6	0 60	1 05	16	6	1	44	11	790.25	7	15	18	77.51	55.01	55.17
11	5	12	18	6	0	11	6	17	6	0.54	1.05	22	0	1	18	8	940 21	6	05	48	92.06	64.06	64.20
12	4	46	19	6	5	12	1	18	6	0.53	1.01	22	0	1	18	8	1136 34	5	02	38	97.25	68.83	68.96
15	3	49	06	7	8	14	10	22	6	0.51	0.99	33	0	0	52	5	1744.38	3	17	01	133.02	92.36	92.46
16	3	34	47	8	0	16	0	24	0	0.50	1.00	33	0	0	52	5	2005 98	2	51	24	135 95	94.95	95.05
18	3	10	56	8	10	17	8	26	6	0 49	0 98	33	0	0	52	5	2587.66	2	12	52	146.38	104.54	104.61
20	2	51	51	9	8	19	4	29	0	0.48	0.97	33	0	0	52	5	3262.98	1	45	22	156.35	113.68	113.76
24	2	23	13	11	4	23	2	34	6	0.47	0.97	33	0	0	52	5	4932 77	1	09	42	175.09	130.66	130.77

In all cases Gage is considered 4 ft. 8½ in. TABLE OF THEORETICAL AND PRACTICAL SWITCH LEADS.

PRACTICAL LEADS

N=Frog Number.	R₁=Radius of Center Line.	D₁=Degree of Lead Curve.			Rectangular Co-ordinates to the Quarter and Center Points on Gage Side of Curved Rail, Referred to Point of Switch Rail as Origin.						T_s=Tangent Adjacent to Switch Rail.	T_f=Tangent Adjacent to Toe of Frog.	L'=Distance Actual Point of Switch Rail to Theoretical Point of Frog.	Lead=Distance Actual Point of Switch Rail to Actual Point of Frog.	Closure for Straight Rail.			Closure for Curved Rail.	
					X	X₁	X₂	Y	Y₁	Y₂									
1	XV	XVI			XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII			XXVIII	
	Feet	Deg.	Min.	Sec.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet					
4	110 69	53	42	24	17.74	23 44	29 75	0.97	1.67	2.79	1 03	0 00	37 77	37.94	1-23.60			1-24	
5	174.34	33	19	57	17 78	24 54	31 27	0.95	1 61	2 62	0 00	0.82	42.26	42.47	1-27.68			1-28	
6	265 39	21	43	04	19 07	27 13	35 15	1.01	1.74	2 72	0 00	0 66	47.73	47.98	1-32.73			1-33	
7	362 08	15	52	29	26 72	36 93	47 11	0 97	1.71	2.74	0 00	0.19	61.81	62.10	1-13.89	1-27		1-14.11	1-27
8	487 48	11	46	27	28 37	39 91	51 45	1.02	1 78	2.91	0.30	0.00	67.65	67.98	1-16.40	1-30		1-16.60	1-30
9	605.18	9	28	42	28 75	40 98	53.19	1.02	1 76	2 75	0 00	0.57	71.91	72.28	1-16.41	1-33		1-16.59	1-33
9½	695.45	8	14	45	30.31	43 35	56 37	1 06	1.82	2.83	0 76	0 00	75.32	75.71	1-25.82	1-27		1-26	1-27
10	790.25	7	15	18	30.28	44 05	57.81	1 06	1.84	2.85	0.00	0.00	77.51	77 93	1-27	1-28		1-27.17	1-28
11	922.65	6	12	47	40 74	56 47	72 19	1 08	1.84	2.87	2.99	0 00	93 85	94.31	1-32.85	1-33		2-33	
13	1098 73	5	12	59	43.99	60 65	77 28	1 15	1 90	2.91	5.33	0 00	100.30	100.80	1-23 88	2-24		3-24	
15	1744.38	3	17	01	55 49	77 95	100.41	1 01	1.78	2.85	0 00	0 00	132.66	133.28	2-33	1-25.9		2-33	1-26
16	1993.24	2	52	59	58.16	81 76	105.35	1 04	1.82	2 87	1.56	0 00	136.90	137.57	1-29.90	2-33		1-30	2-33
18	2546.31	2	14	31	58 73	84 46	110 10	1 04	1 82	2.86	0 00	1.08	145.76	146.51	1-25.93	3-26		4-26	
20	3257.26	1	45	32	61.84	90.21	118.59	1 08	1 88	2.93	0 44	0.00	156.59	157.42	1-26.92	2-27	1-33	3-27	1-33
24	4886.16	1	10	21	67.82	100 21	132.59	1 27	1.97	3 00	2 43	0 00	176.22	177.22	1-32.89	3-33		4-33	

*MAINTENANCE OF LINE.

(a) *Adjustment of Tangents:*

Tangents should be adjusted by throwing the tangent between summits; between curves; or by throwing curves to meet tangents; or by partially throwing curves and partially throwing tangents, as may require the least work. Centers should be set with transit to insure accurate line.

(b) *Adjustment of Curves, with consideration as to Easement Curves:*

Easement curves should be used on all curves requiring an elevation of 2 in. or more for the highest permissible speed.

The choice of easement curves should be governed by the ultimate possibilities as to speed, with consideration as to probable revision of the worst features of alinement, rather than by existing schedule speed.

On curves of 6 degrees and over which are limiting curves as to speed, easement curves not less than 240 ft. long should be used.

On curves of less than 6 degrees which are limiting curves as to speed, easement curves should be used whose length in feet is not less than 5⅓ times the speed in miles per hour calculated for an elevation of 8 in.

On curves which are not limiting curves as to speed, easement curves should be used whose length in feet, when the rail is elevated for the ultimate speed, will be not less than thirty times the elevation in inches nor less than two-thirds the ultimate speed in miles per hour times the elevation in inches.

Longer easement curves than the minimum lengths recommended may be used to advantage and often with increased convenience in their application, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration as to the effect on cost. For minor curves, an increase in length of about 50 per cent. over the minimum is recommended when such increase will not seriously affect the cost, nor adversely affect the degree of curve. The minimum length recommended should be used in all cases where greater length would adversely affect the degree of curve.

Easement curves should be used between curves of different degree in the same way that they are used between curves and tangents.

The curve elevation should be run out in the same distance as the length of easement curve, with no elevation on tangent and full elevation on the circular curve.

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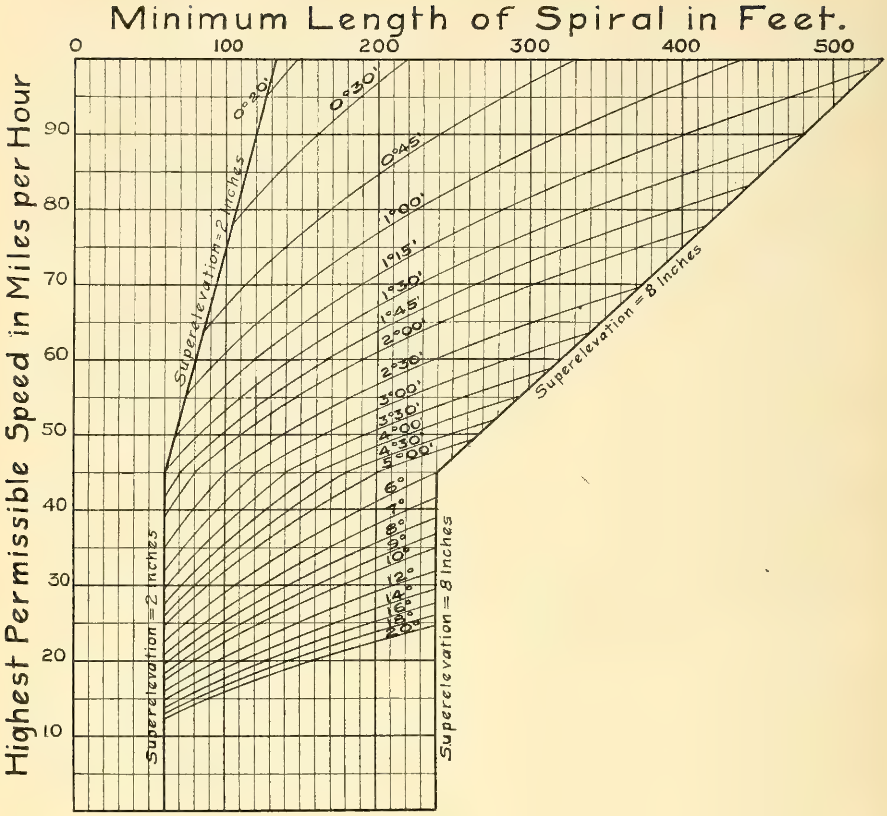
* Adopted, Vol. 3, 1902, pp. 55, 56, 67-78; Vol. 5, 1904, pp. 527, 528, 535, 561, 562; Vol. 6, 1905, pp. 753, 754, 759-761; Vol. 10, 1909, pp. 400, 429, 430, 461-463, 464; Vol. 12, 1911.

Any form of easement curve is satisfactory in which the degree of curve increases with the distance; in which the rate of increase in degree of curve can readily be changed to suit each particular case, so that the length of easement curve shall be the same as the distance in which the outer rail is raised from zero to full elevation; which can be run in by deflection or offset, with chords of any desired length, and which is of the general type of the Searles, Crandall, Holbrook, or Talbot spiral, or cubic parabola.

The 10-chord spiral, computed by dividing the spiral into 10 equal parts, is recommended. Chords of any length may be used in staking out the 10-chord spiral when the central angle is small. Chords approximating one-tenth the length of spiral should be used when the central angle exceeds 15 degrees.

(c) *Method of Securing and Maintaining Perfect Line:*

Permanent witnesses should be placed at points of tangent, points of spiral, points of change of curvature, summits, and at such other points along curves or tangents as will enable the alinement to be identically reproduced with a transit.



MINIMUM LENGTH OF EASEMENT CURVE.

Limiting Curves.

For all curves which are liable to limit the speed of trains, the length of spiral should equal that indicated on the line marked "Superelevation=8 inches." Longer spirals may be used provided the increased length does not adversely affect the degree of curve or seriously affect the cost of construction.

Minor Curves.

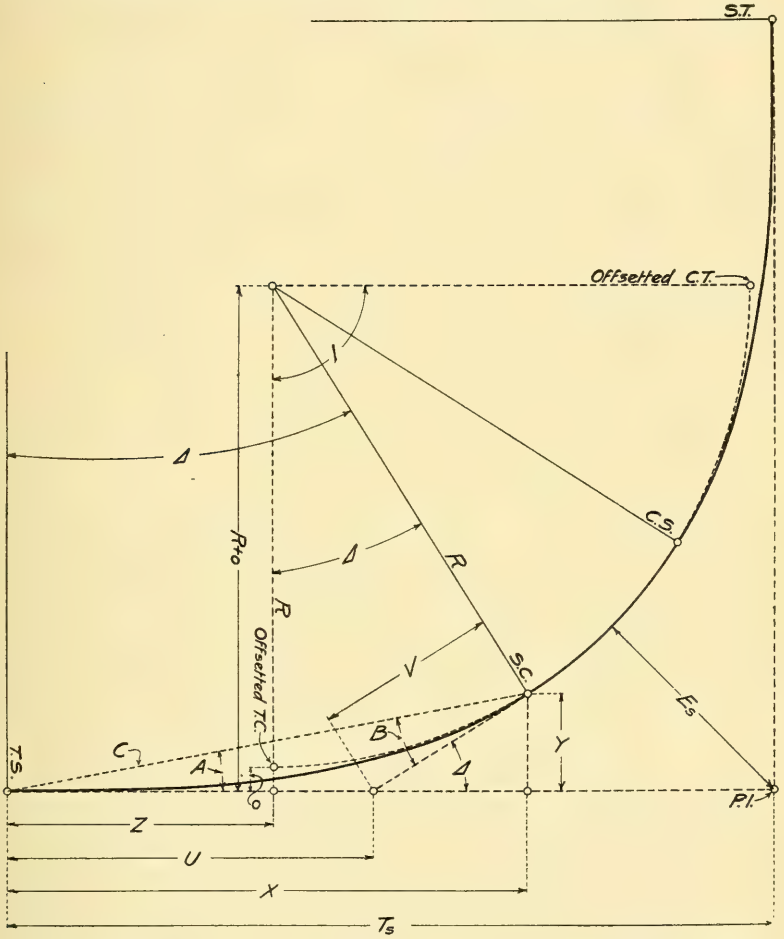
For minor curves the length of spiral should never be less than that indicated by the diagram; an increase of about 50 per cent. over the indicated length may be desirable where cost is not seriously affected.

Spirals need not be used when superelevation required for highest permissible speed is less than two inches.

* SPIRALS.

NOTATION.

For curve points, the first initial represents the alinement on the side toward station zero, the second that away from station zero.


S.T.
Offsetted C.T.
I
Δ
R+o
Δ
R
R
Offsetted T.C.
C.S.
V
S.C.
E_s
B
C
A
Δ
Y
T.S.
o
P.I.
Z
U
X
T_s

T. C. The point of change in alinement from tangent to circular curve.

C. T. The point of change from circular curve to tangent.

C. C. The point of change in degree of circular curve; the point of compound curve, the point of reverse curve.

T. S. The point of change from tangent to spiral.

S. C. The point of change from spiral to circular curve.

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* **Adopted, Vol. 12, Part 1, 1911.**

C. S.	The point of change from circular curve to spiral.
S. T.	The point of change from spiral to tangent.
S. S.	The point of change from one spiral to another.

The symbols *T. C.* and *C. T.*, *T. S.* and *S. T.*, and *S. C.* and *C. S.* become transposed when the direction of stationing is changed.

a	The angle between the tangent at the *T. S.* and the chord from the *T. S.* to any point on the spiral.
A	The angle between the tangent at the *T. S.* and the chord from the *T. S.* to the *S. C.*
b	The angle at any point on the spiral, between the tangent at that point and the chord from the *T. S.*
B	The angle at the *S. C.* between the chord from the *T. S.* and the tangent at the *S. C.*
c	The chord from the *T. S.* to any point on the spiral.
C	The chord from the *T. S.* to the *S. C.*
d	The degree of curve at any point on the spiral.
D	The degree of central circular curve.
f	The angle between any chord of the spiral (produced if necessary) and the tangent through the *T. S.*
I	The angle between the initial and final tangents; the total central angle of circular curve and spirals.
k	The increase in degree of curve per station on the spiral.
l	The length of the spiral in feet from the *T. S.* to any given point.
L	The length of the spiral in feet from the *T. S.* to the *S. C.*
o	The ordinate of the offsetted *T. C.*; the distance between the tangent and a parallel tangent to the offsetted curve.
r	The radius of the osculating circle at any given point of the spiral.
R	The radius of the central circular curve.
s	The length of the spiral in stations from the *T. S.* to any given point.
S	The length of the spiral in stations from the *T. S.* to the *S. C.*
u	The distance on the tangent from the *T. S.* to the intersection with a tangent through any given point of the spiral.
U	The distance on the tangent from the *T. S.* to the intersection with a tangent through the *S. C.*; the longer spiral tangent.
v	The distance on the tangent through any given point from that point to the intersection with the tangent through the *T. S.*
V	The distance on the tangent through the *S. C.* from the *S. C.* to the intersection with the tangent through the *T. S.*; the shorter spiral tangent.

x The abscissa or tangent distance of any given point, referred to the *T. S.*

X The abscissa or tangent distance of the *S. C.*, referred to the *T. S.*

y The ordinate or tangent offset of any point.

Y The ordinate or tangent offset of the *S. C.*

Z The abscissa or tangent distance of the offsetted *T. C.*, referred to the *T. S.*

δ The central angle of the spiral from the *T. S.* to any given point.

Δ The central angle of the whole spiral.

T_s The tangent distance of the spiraled curve; distance from *T. S.* to *P. I.* (point of intersection of tangents).

E_s The external distance of the offsetted curve.

FORMULAS FOR THE EXACT DETERMINATION OF THE FUNCTIONS OF THE TEN-CHORD SPIRAL WHEN THE CENTRAL ANGLE DOES NOT EXCEED 45 DEGREES.

$$\left.\begin{aligned} d &= ks = \frac{kl}{100} \\ D &= kS = \frac{kL}{100} \end{aligned}\right\} \quad \text{(1)}$$

$$\left.\begin{aligned} \delta &= \frac{ks^2}{2} = \frac{ds}{2} = \frac{kl^2}{20000} = \frac{dl}{200} \\ \Delta &= \frac{kS^2}{2} = \frac{DS}{2} = \frac{kL^2}{20000} = \frac{DL}{200} \end{aligned}\right\} \quad \text{(2)}$$

$$A = \tfrac{1}{3}\Delta - 0.00297\,\Delta^3 \text{ seconds} \quad \text{(3)}$$

$$B = \Delta - A \quad \text{(4)}$$

$$C = L\,(\cos 0.3\,\Delta + .004\,\text{exsec}\,\tfrac{3}{4}\,\Delta) \quad \text{(5)}$$

$$X = C \cos A \quad \text{(6)}$$

$$Y = C \sin A \quad \text{(7)}$$

$$U = C\frac{\sin B}{\sin \Delta} \quad \text{(8)}$$

$$V = C\frac{\sin A}{\sin \Delta} \quad \text{(9)}$$

$$R = \frac{50}{\sin \tfrac{1}{2} D} \quad \text{(10)}$$

$$Z = X - R \sin \Delta \quad \text{(11)}$$

$$o = Y - R \,\text{vers}\, \Delta \quad \text{(12)}$$

$$T_s = (R + o) \tan (\tfrac{1}{2} I) + Z \quad \text{(13)}$$

$$E_s = (R + o)\,\text{exsec}\,(\tfrac{1}{2} I) + o \quad \text{(14)}$$

FORMULAS FOR FIELD USE.

The formulas presented above are best adapted for the preparation of tables. For use in the field, the following empirical formulas are sufficiently accurate and have the advantage that they do not require the computation of the long chord. The formulas can all be applied for the functions of any parts of the spiral without serious error, though they are derived for the completed spiral.

$$\left.\begin{aligned} a &= \tfrac{1}{3}\,\delta \\ A &= \tfrac{1}{3}\,\Delta \end{aligned}\right\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

$$\left.\begin{aligned} a &= 10\,ks^2\ minutes \\ A &= 10\,kS^2\ minutes \end{aligned}\right\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Formulas (15) and (16) are sufficiently accurate for turning deflections when δ (or Δ) does not exceed 15°.

A similar approximation may be used when the transit is set at an intermediate point on the spiral if the included central angle from the transit point to the point of sight, less the included angle from the T. S. to the transit point, does not exceed 15°.

$$X = L - L\left(\tfrac{1}{3}\,vers\,\tfrac{3}{4}\,\Delta + {}^{1}/_{22}\ vers\,\tfrac{1}{2}\,\Delta\right) \ldots\ldots\ldots\ldots (17)$$

$$Y = \frac{L}{39}\left(20\,sin\,\tfrac{1}{2}\,\Delta + 3\,sin\,\Delta\right) \ldots\ldots\ldots\ldots (18)$$

$$U = L\left(\tfrac{2}{3} + {}^{10}/_{39}\ exsec\,\tfrac{1}{2}\,\Delta + {}^{1}/_{10}\ vers\,\tfrac{1}{4}\,\Delta\right) \ldots\ldots\ldots\ldots (19)$$

$$V = L\left(\tfrac{1}{3} + {}^{10}/_{39}\ exsec\,\tfrac{1}{2}\,\Delta\right) \ldots\ldots\ldots\ldots (20)$$

$$o = \frac{L}{10}\left(sin\,\tfrac{1}{2}\,\Delta + sin\,\tfrac{1}{3}\,\Delta\right) cos\,\tfrac{1}{2}\,D \ldots\ldots\ldots\ldots (21)$$

$$Z = L\left(0.5 - .12885\,vers\,\tfrac{1}{2}\,\Delta\right) - .073\,D\,sin\,\Delta \ldots\ldots\ldots\ldots (22)$$

$$L = \frac{370.82}{cos^{\,21/60}\,D}\left(1 + .000018\,Do\right)\sqrt{\frac{o}{D}} \ldots\ldots\ldots\ldots (23)$$

STAKING SPIRALS BY DEFLECTIONS.

In staking by deflections, considerable convenience is sometimes found in dividing the spiral in ten equal chords, conforming to the theory upon which the formulas are based. The first deflection in minutes equals the degree of the main or central curve times the length of chord in stations. For example, for a spiral $L = 500$ and $D = 4°$, $s_1 = 0.5$ and $a_1 = 4 \times 0.5 = 2$ minutes; the remaining deflections are 4, 9, 16, 25, etc., times the initial deflection.

The following table gives the coefficient by which the first chord deflection is to be multiplied to give the deflection to other chord points for various positions of the transit.

COEFFICIENTS OF a_1 FOR DEFLECTION ANGLES TO CHORD POINTS

Deflection Angle to Chord Point Number	Transit at Chord-Point Number										
	0 T. S.	1	2	3	4	5	6	7	8	9	10 S. C.
0 T. S.	0	2	8	18	32	50	72	98	128	162	200
1	1	0	5	14	27	44	65	90	119	152	189
2	4	4	0	8	20	36	56	80	108	140	176
3	9	10	7	0	11	26	45	68	95	126	161
4	16	18	16	10	0	14	32	54	80	110	144
5	25	28	27	22	13	0	17	38	63	92	125
6	36	40	40	36	28	16	0	20	44	72	104
7	49	54	55	52	45	34	19	0	23	50	81
8	64	70	72	70	64	54	40	22	0	26	56
9	81	88	91	90	85	76	63	46	25	0	29
10 S. C.	100	108	112	112	108	100	88	72	52	28	0

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
0.0°	0° 00′ 00″	1.000 000	1.000 000	.000 000
0.1°	0° 02′ 00″	1.000 000	1.000 000	.000 582
0.2°	0° 04′ 00″	.999 999	.999 999	.001 164
0.3°	0° 06′ 00″	.999 999	.999 997	.001 745
0.4°	0° 08′ 00″	.999 998	.999 995	.002 327
0.5°	0° 10′ 00″	.999 997	.999 993	.002 909
0.6°	0° 12′ 00″	.999 995	.999 989	.003 491
0.7°	0° 14′ 00″	.999 993	.999 985	.004 072
0.8°	0° 16′ 00″	.999 991	.999 981	.004 654
0.9°	0° 18′ 00″	.999 989	.999 975	.005 236
1.0°	0° 20′ 00″	.999 987	.999 970	.005 818
1.1°	0° 22′ 00″	.999 984	.999 963	.006 399
1.2°	0° 24′ 00″	.999 981	.999 956	.006 981
1.3°	0° 26′ 00″	.999 977	.999 949	.007 563
1.4°	0° 28′ 00″	.999 974	.999 941	.008 145
1.5°	0° 30′ 00″	.999 970	.999 932	.008 726
1.6°	0° 32′ 00″	.999 966	.999 923	.009 308
1.7°	0° 34′ 00″	.999 961	.999 913	.009 890
1.8°	0° 36′ 00″	.999 957	.999 902	.010 471
1.9°	0° 38′ 00″	.999 952	.999 891	.011 053
2.0°	0° 40′ 00″	.999 947	.999 879	.011 635
2.1°	0° 42′ 00″	.999 941	.999 867	.012 216
2.2°	0° 44′ 00″	.999 935	.999 853	.012 798
2.3°	0° 46′ 00″	.999 929	.999 840	.013 379
2.4°	0° 48′ 00″	.999 923	.999 826	.013 961
2.5°	0° 50′ 00″	.999 916	.999 811	.014 542
2.6°	0° 52′ 00″	.999 910	.999 795	.015 124
2.7°	0° 54′ 00″	.999 903	.999 779	.015 706
2.8°	0° 56′ 00″	.999 895	.999 763	.016 287
2.9°	0° 58′ 00″	.999 888	.999 745	.016 868
3.0°	1° 00′ 00″	.999 880	.999 727	.017 450
3.1°	1° 02′ 00″	.999 872	.999 709	.018 031
3.2°	1° 04′ 00″	.999 863	.999 690	.018 613
3.3°	1° 06′ 00″	.999 854	.999 670	.019 194
3.4°	1° 08′ 00″	.999 845	.999 650	.019 776
3.5°	1° 10′ 00″	.999 836	.999 629	.020 357
3.6°	1° 12′ 00″	.999 827	.999 607	.020 938
3.7°	1° 14′ 00″	.999 817	.999 585	.021 519
3.8°	1° 16′ 00″	.999 807	.999 563	.022 101
3.9°	1° 18′ 00″	.999 797	.999 539	.022 682
4.0°	1° 20′ 00″	.999 786	.999 515	.023 263
4.1°	1° 22′ 00″	.999 775	.999 491	.023 844
4.2°	1° 24′ 00″	.999 764	.999 466	.024 425
4.3°	1° 26′ 00″	.999 753	.999 440	.025 006
4.4°	1° 28′ 00″	.999 741	.999 414	.025 588
4.5°	1° 30′ 00″	.999 729	.999 387	.026 169
4.6°	1° 32′ 00″	.999 717	.999 359	.026 750
4.7°	1° 34′ 00″	.999 705	.999 331	.027 330
4.8°	1° 36′ 00″	.999 692	.999 302	.027 911
4.9°	1° 38′ 00″	.999 679	.999 273	.028 492
5.0°	1° 40′ 00″	.999 666	.999 243	.029 073

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
5.0°	1° 40′ 00″	.999 666	.999 243	.029 073
5.1°	1° 42′ 00″	.999 652	.999 212	.029 654
5.2°	1° 44′ 00″	.999 639	.999 181	.030 235
5.3°	1° 46′ 00″	.999 625	.999 149	.030 816
5.4°	1° 48′ 00″	.999 610	.999 117	.031 396
5.5°	1° 50′ 00″	.999 596	.999 084	.031 977
5.6°	1° 51′ 59″	.999 581	.999 051	.032 558
5.7°	1° 53′ 59″	.999 566	.999 016	.033 138
5.8°	1° 55′ 59″	.999 550	.998 982	.033 719
5.9°	1° 57′ 59″	.999 535	.998 946	.034 299
6.0°	1° 59′ 59″	.999 519	.998 910	.034 880
6.1°	2° 01′ 59″	.999 503	.998 873	.035 460
6.2°	2° 03′ 59″	.999 486	.998 836	.036 040
6.3°	2° 05′ 59″	.999 470	.998 799	.036 621
6.4°	2° 07′ 59″	.999 453	.998 760	.037 201
6.5°	2° 09′ 59″	.999 435	.998 721	.037 781
6.6°	2° 11′ 59″	.999 418	.998 681	.038 361
6.7°	2° 13′ 59″	.999 400	.998 641	.038 941
6.8°	2° 15′ 59″	.999 382	.998 600	.039 522
6.9°	2° 17′ 59″	.999 364	.998 559	.040 102
7.0°	2° 19′ 59″	.999 345	.998 517	.040 681
7.1°	2° 21′ 59″	.999 326	.998 474	.041 261
7.2°	2° 23′ 59″	.999 307	.998 431	.041 841
7.3°	2° 25′ 59″	.999 288	.998 387	.042 421
7.4°	2° 27′ 59″	.999 268	.998 343	.043 001
7.5°	2° 29′ 59″	.999 248	.998 298	.043 581
7.6°	2° 31′ 59″	.999 228	.998 252	.044 160
7.7°	2° 33′ 59″	.999 208	.998 206	.044 740
7.8°	2° 35′ 59″	.999 187	.998 159	.045 319
7.9°	2° 37′ 59″	.999 166	.998 111	.045 899
8.0°	2° 39′ 58″	.999 145	.998 063	.046 478
8.1°	2° 41′ 58″	.999 123	.998 015	.047 058
8.2°	2° 43′ 58″	.999 102	.997 965	.047 637
8.3°	2° 45′ 58″	.999 080	.997 916	.048 216
8.4°	2° 47′ 58″	.999 057	.997 865	.048 795
8.5°	2° 49′ 58″	.999 035	.997 814	.049 374
8.6°	2° 51′ 58″	.999 012	.997 762	.049 953
8.7°	2° 53′ 58″	.998 989	.997 710	.050 532
8.8°	2° 55′ 58″	.998 965	.997 657	.051 111
8.9°	2° 57′ 58″	.998 942	.997 603	.051 690
9.0°	2° 59′ 58″	.998 918	.997 549	.052 269
9.1°	3° 01′ 58″	.998 894	.997 494	.052 848
9.2°	3° 03′ 58″	.998 869	.997 439	.053 426
9.3°	3° 05′ 58″	.998 844	.997 383	.054 005
9.4°	3° 07′ 58″	.998 819	.997 327	.054 583
9.5°	3° 09′ 57″	.998 794	.997 270	.055 162
9.6°	3° 11′ 57″	.998 769	.997 212	.055 740
9.7°	3° 13′ 57″	.998 743	.997 154	.056 318
9.8°	3° 15′ 57″	.998 717	.997 095	.056 897
9.9°	3° 17′ 57″	.998 691	.997 035	.057 475
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053
10.1°	3° 21′ 57″	.998 637	.996 915	.058 631
10.2°	3° 23′ 57″	.998 610	.996 853	.059 209
10.3°	3° 25′ 57″	.998 583	.996 791	.059 787
10.4°	3° 27′ 57″	.998 555	.996 729	.060 364
10.5°	3° 29′ 57″	.998 527	.996 666	.060 942
10.6°	3° 31′ 56″	.998 499	.996 602	.061 520
10.7°	3° 33′ 56″	.998 471	.996 538	.062 097
10.8°	3° 35′ 56″	.998 442	.996 473	.062 675
10.9°	3° 37′ 56″	.998 413	.996 407	.063 252
11.0°	3° 39′ 56″	.998 384	.996 341	.063 829
11.1°	3° 41′ 56″	.998 354	.996 274	.064 406
11.2°	3° 43′ 56″	.998 324	.996 207	.064 984
11.3°	3° 45′ 56″	.998 294	.996 139	.065 561
11.4°	3° 47′ 56″	.998 264	.996 071	.066 138
11.5°	3° 49′ 55″	.998 233	.996 002	.066 714
11.6°	3° 51′ 55″	.998 203	.995 932	.067 291
11.7°	3° 53′ 55″	.998 172	.995 862	.067 868
11.8°	3° 55′ 55″	.998 140	.995 791	.068 445
11.9°	3° 57′ 55″	.998 109	.995 719	.069 021
12.0°	3° 59′ 55″	.998 077	.995 647	.069 598
12.1°	4° 01′ 55″	.998 044	.995 574	.070 174
12.2°	4° 03′ 55″	.998 012	.995 501	.070 750
12.3°	4° 05′ 54″	.997 979	.995 427	.071 326
12.4°	4° 07′ 54″	.997 946	.995 353	.071 902
12.5°	4° 09′ 54″	.997 913	.995 278	.072 478
12.6°	4° 11′ 54″	.997 880	.995 202	.073 054
12.7°	4° 13′ 54″	.997 846	.995 126	.073 630
12.8°	4° 15′ 54″	.997 812	.995 049	.074 206
12.9°	4° 17′ 54″	.997 777	.994 971	.074 781
13.0°	4° 19′ 53″	.997 743	.994 893	.075 357
13.1°	4° 21′ 53″	.997 708	.994 814	.075 932
13.2°	4° 23′ 53″	.997 673	.994 735	.076 508
13.3°	4° 25′ 53″	.997 638	.994 655	.077 083
13.4°	4° 27′ 53″	.997 602	.994 575	.077 658
13.5°	4° 29′ 53″	.997 566	.994 494	.078 233
13.6°	4° 31′ 53″	.997 530	.994 412	.078 808
13.7°	4° 33′ 52″	.997 493	.994 330	.079 383
13.8°	4° 35′ 52″	.997 457	.994 247	.079 957
13.9°	4° 37′ 52″	.997 420	.994 163	.080 532
14.0°	4° 39′ 52″	.997 383	.994 079	.081 106
14.1°	4° 41′ 52″	.997 345	.993 995	.081 681
14.2°	4° 43′ 51″	.997 307	.993 909	.082 255
14.3°	4° 45′ 51″	.997 269	.993 823	.082 829
14.4°	4° 47′ 51″	.997 231	.993 737	.083 403
14.5°	4° 49′ 51″	.997 192	.993 650	.083 977
14.6°	4° 51′ 51″	.997 154	.993 562	.084 551
14.7°	4° 53′ 51″	.997 115	.993 474	.085 125
14.8°	4° 55′ 50″	.997 075	.993 385	.085 699
14.9°	4° 57′ 50″	.997 036	.993 296	.086 272
15.0°	4° 59′ 50″	.996 996	.993 206	.086 846

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
15.0°	4° 59′ 50″	.996 996	.993 206	.086 846
15.1°	5° 01′ 50″	.996 956	.993 115	.087 419
15.2°	5° 03′ 50″	.996 915	.993 024	.087 992
15.3°	5° 05′ 49″	.996 874	.992 932	.088 565
15.4°	5° 07′ 49″	.996 833	.992 840	.089 138
15.5°	5° 09′ 49″	.996 792	.992 747	.089 711
15.6°	5° 11′ 49″	.996 751	.992 653	.090 284
15.7°	5° 13′ 49″	.996 709	.992 559	.090 857
15.8°	5° 15′ 48″	.996 667	.992 465	.091 429
15.9°	5° 17′ 48″	.996 625	.992 369	.092 001
16.0°	5° 19′ 48″	.996 582	.992 273	.092 574
16.1°	5° 21′ 48″	.996 539	.992 177	.093 146
16.2°	5° 23′ 47″	.996 496	.992 080	.093 718
16.3°	5° 25′ 47″	.996 453	.991 982	.094 290
16.4°	5° 27′ 47″	.996 409	.991 884	.094 862
16.5°	5° 29′ 47″	.996 366	.991 785	.095 433
16.6°	5° 31′ 46″	.996 321	.991 685	.096 005
16.7°	5° 33′ 46″	.996 277	.991 585	.096 576
16.8°	5° 35′ 46″	.996 232	.991 484	.097 148
16.9°	5° 37′ 46″	.996 187	.991 383	.097 719
17.0°	5° 39′ 45″	.996 142	.991 281	.098 290
17.1°	5° 41′ 45″	.996 097	.991 179	.098 861
17.2°	5° 43′ 45″	.996 051	.991 076	.099 432
17.3°	5° 45′ 45″	.996 005	.990 972	.100 002
17.4°	5° 47′ 44″	.995 959	.990 868	.100 573
17.5°	5° 49′ 44″	.995 912	.990 763	.101 143
17.6°	5° 51′ 44″	.995 865	.990 657	.101 713
17.7°	5° 53′ 44″	.995 818	.990 551	.102 284
17.8°	5° 55′ 43″	.995 771	.990 445	.102 854
17.9°	5° 57′ 43″	.995 723	.990 338	.103 424
18.0°	5° 59′ 43″	.995 676	.990 230	.103 993
18.1°	6° 01′ 42″	.995 627	.990 122	.104 563
18.2°	6° 03′ 42″	.995 579	.990 013	.105 132
18.3°	6° 05′ 42″	.995 530	.989 903	.105 702
18.4°	6° 07′ 42″	.995 482	.989 793	.106 271
18.5°	6° 09′ 41″	.995 432	.989 682	.106 840
18.6°	6° 11′ 41″	.995 383	.989 571	.107 409
18.7°	6° 13′ 41″	.995 333	.989 459	.107 978
18.8°	6° 15′ 40″	.995 283	.989 346	.108 547
18.9°	6° 17′ 40″	.995 233	.989 233	.109 115
19.0°	6° 19′ 40″	.995 183	.989 120	.109 683
19.1°	6° 21′ 39″	.995 132	.989 005	.110 252
19.2°	6° 23′ 39″	.995 081	.988 891	.110 820
19.3°	6° 25′ 39″	.995 029	.988 775	.111 388
19.4°	6° 27′ 38″	.994 978	.988 659	.111 956
19.5°	6° 29′ 38″	.994 926	.988 543	.112 523
19.6°	6° 31′ 38″	.994 874	.988 425	.113 091
19.7°	6° 33′ 37″	.994 822	.988 308	.113 658
19.8°	6° 35′ 37″	.994 769	.988 189	.114 226
19.9°	6° 37′ 37″	.994 716	.988 070	.114 793
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360
20.1°	6° 41′ 36″	.994 610	.987 830	.115 926
20.2°	6° 43′ 36″	.994 556	.987 710	.116 493
20.3°	6° 45′ 35″	.994 502	.987 589	.117 059
20.4°	6° 47′ 35″	.994 448	.987 467	.117 626
20.5°	6° 49′ 34″	.994 393	.987 344	.118 192
20.6°	6° 51′ 34″	.994 339	.987 221	.118 758
20.7°	6° 53′ 34″	.994 284	.987 097	.119 324
20.8°	6° 55′ 33″	.994 228	.986 973	.119 890
20.9°	6° 57′ 33″	.994 173	.986 849	.120 455
21.0°	6° 59′ 32″	.994 117	.986 723	.121 021
21.1°	7° 01′ 32″	.994 061	.986 597	.121 586
21.2°	7° 03′ 32″	.994 005	.986 471	.122 151
21.3°	7° 05′ 31″	.993 948	.986 343	.122 716
21.4°	7° 07′ 31″	.993 891	.986 216	.123 281
21.5°	7° 09′ 30″	.993 834	.986 088	.123 846
21.6°	7° 11′ 30″	.993 777	.985 959	.124 410
21.7°	7° 13′ 30″	.993 719	.985 829	.124 974
21.8°	7° 15′ 29″	.993 661	.985 699	.125 539
21.9°	7° 17′ 29″	.993 603	.985 568	.126 103
22.0°	7° 19′ 28″	.993 545	.985 437	.126 667
22.1°	7° 21′ 28″	.993 486	.985 305	.127 230
22.2°	7° 23′ 28″	.993 427	.985 173	.127 794
22.3°	7° 25′ 27″	.993 368	.985 040	.128 357
22.4°	7° 27′ 27″	.993 308	.984 906	.128 920
22.5°	7° 29′ 26″	.993 248	.984 772	.129 483
22.6°	7° 31′ 26″	.993 188	.984 638	.130 046
22.7°	7° 33′ 25″	.993 128	.984 502	.130 609
22.8°	7° 35′ 25″	.993 068	.984 366	.131 172
22.9°	7° 37′ 24″	.993 007	.984 230	.131 734
23.0°	7° 39′ 24″	.992 946	.984 093	.132 296
23.1°	7° 41′ 23″	.992 884	.983 955	.132 858
23.2°	7° 43′ 23″	.992 823	.983 817	.133 420
23.3°	7° 45′ 22″	.992 761	.983 678	.133 982
23.4°	7° 47′ 22″	.992 699	.983 539	.134 543
23.5°	7° 49′ 21″	.992 636	.983 399	.135 105
23.6°	7° 51′ 21″	.992 574	.983 258	.135 666
23.7°	7° 53′ 20″	.992 511	.983 117	.136 227
23.8°	7° 55′ 20″	.992 448	.982 976	.136 788
23.9°	7° 57′ 19″	.992 384	.982 834	.137 348
24.0°	7° 59′ 19″	.992 321	.982 691	.137 909
24.1°	7° 01′ 18″	.992 257	.982 547	.138 469
24.2°	8° 03′ 18″	.992 192	.982 403	.139 029
24.3°	8° 05′ 17″	.992 128	.982 259	.139 589
24.4°	8° 07′ 17″	.992 063	.982 114	.140 149
24.5°	8° 09′ 16″	.991 998	.981 968	.140 708
24.6°	8° 11′ 16″	.991 933	.981 822	.141 268
24.7°	8° 13′ 15″	.991 867	.981 675	.141 827
24.8°	8° 15′ 15″	.991 801	.981 528	.142 386
24.9°	8° 17′ 14″	.991 735	.981 380	.142 945
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504
25.1°	8° 21′ 13″	.991 602	.981 082	.144 062
25.2°	8° 23′ 12″	.991 536	.980 932	.144 620
25.3°	8° 25′ 12″	.991 468	.980 782	.145 179
25.4°	8° 27′ 11″	.991 401	.980 631	.145 737
25.5°	8° 29′ 11″	.991 333	.980 479	.146 294
25.6°	8° 31′ 10″	.991 265	.980 327	.146 852
25.7°	8° 33′ 10″	.991 197	.980 175	.147 409
25.8°	8° 35′ 09″	.991 129	.980 022	.147 966
25.9°	8° 37′ 08″	.991 060	.979 868	.148 523
26.0°	8° 39′ 08″	.990 991	.979 714	.149 080
26.1°	8° 41′ 07″	.990 922	.979 559	.149 637
26.2°	8° 43′ 07″	.990 853	.979 403	.150 193
26.3°	8° 45′ 06″	.990 783	.979 247	.150 750
26.4°	8° 47′ 05″	.990 713	.979 090	.151 306
26.5°	8° 49′ 05″	.990 642	.978 933	.151 861
26.6°	8° 51′ 04″	.990 572	.978 776	.152 417
26.7°	8° 53′ 03″	.990 501	.978 617	.152 973
26.8°	8° 55′ 03″	.990 430	.978 459	.153 528
26.9°	8° 57′ 02″	.990 359	.978 299	.154 083
27.0°	8° 59′ 02″	.990 287	.978 139	.154 638
27.1°	9° 01′ 01″	.990 215	.977 978	.155 193
27.2°	9° 03′ 00″	.990 143	.977 817	.155 747
27.3°	9° 05′ 00″	.990 071	.977 655	.156 301
27.4°	9° 06′ 59″	.989 998	.977 493	.156 855
27.5°	9° 08′ 58″	.989 925	.977 330	.157 409
27.6°	9° 10′ 58″	.989 852	.977 167	.157 963
27.7°	9° 12′ 57″	.989 779	.977 003	.158 516
27.8°	9° 14′ 56″	.989 705	.976 838	.159 070
27.9°	9° 16′ 55″	.989 631	.976 673	.159 623
28.0°	9° 18′ 55″	.989 557	.976 508	.160 176
28.1°	9° 20′ 54″	.989 482	.976 341	.160 728
28.2°	9° 22′ 53″	.989 408	.976 174	.161 281
28.3°	9° 24′ 53″	.989 333	.976 007	.161 833
28.4°	9° 26′ 52″	.989 257	.975 839	.162 385
28.5°	9° 28′ 51″	.989 182	.975 670	.162 937
28.6°	9° 30′ 51″	.989 106	.975 500	.163 489
28.7°	9° 32′ 50″	.989 030	.975 331	.164 040
28.8°	9° 34′ 49″	.988 954	.975 161	.164 591
28.9°	9° 36′ 48″	.988 877	.974 990	.165 142
29.0°	9° 38′ 48″	.988 800	.974 819	.165 693
29.1°	9° 40′ 47″	.988 723	.974 647	.166 244
29.2°	9° 42′ 46″	.988 646	.974 475	.166 794
29.3°	9° 44′ 45″	.988 568	.974 301	.167 344
29.4°	9° 46′ 45″	.988 491	.974 128	.167 894
29.5°	9° 48′ 44″	.988 412	.973 954	.168 444
29.6°	9° 50′ 43″	.988 334	.973 779	.168 993
29.7°	9° 52′ 42″	.988 255	.973 604	.169 543
29.8°	9° 54′ 41″	.988 176	.973 428	.170 092
29.9°	9° 56′ 41″	.988 097	.973 251	.170 641
30.0°	9° 58′ 40″	.988 018	.973 074	.171 189

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—**Cont'd.**

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
30.0°	9° 58′ 40″	.988 018	.973 074	.171 189
30.1°	10° 00′ 39″	.987 938	.972 897	.171 738
30.2°	10° 02′ 38″	.987 858	.972 719	.172 286
30.3°	10° 04′ 37″	.987 778	.972 540	.172 834
30.4°	10° 06′ 37″	.987 698	.972 361	.173 382
30.5°	10° 08′ 36″	.987 617	.972 181	.173 929
30.6°	10° 10′ 35″	.987 536	.972 000	.174 477
30.7°	10° 12′ 34″	.987 455	.971 820	.175 023
30.8°	10° 14′ 33″	.987 373	.971 638	.175 571
30.9°	10° 16′ 32″	.987 291	.971 456	.176 117
31.0°	10° 18′ 32″	.987 209	.971 273	.176 664
31.1°	10° 20′ 31″	.987 127	.971 090	.177 210
31.2°	10° 22′ 30″	.987 044	.970 907	.177 756
31.3°	10° 24′ 29″	.986 962	.970 722	.178 302
31.4°	10° 26′ 28″	.986 879	.970 537	.178 847
31.5°	10° 28′ 27″	.986 795	.970 352	.179 392
31.6°	10° 30′ 26″	.986 712	.970 166	.179 938
31.7°	10° 32′ 25″	.986 628	.969 980	.180 482
31.8°	10° 34′ 24″	.986 544	.969 792	.181 027
31.9°	10° 36′ 24″	.986 459	.969 605	.181 571
32.0°	10° 38′ 23″	.986 375	.969 417	.182 116
32.1°	10° 40′ 22″	.986 290	.969 228	.182 659
32.2°	10° 42′ 21″	.986 205	.969 039	.183 203
32.3°	10° 44′ 20″	.986 119	.968 849	.183 747
32.4°	10° 46′ 19″	.986 033	.968 658	.184 290
32.5°	10° 48′ 18″	.985 948	.968 468	.184 833
32.6°	10° 50′ 17″	.985 861	.968 276	.185 376
32.7°	10° 52′ 16″	.985 775	.968 084	.185 918
32.8°	10° 54′ 15″	.985 688	.967 891	.186 460
32.9°	10° 56′ 14″	.985 601	.967 698	.187 002
33.0°	10° 58′ 13″	.985 514	.967 504	.187 544
33.1°	11° 00′ 12″	.985 426	.967 310	.188 086
33.2°	11° 02′ 11″	.985 339	.967 115	.188 627
33.3°	11° 04′ 10″	.985 251	.966 920	.189 168
33.4°	11° 06′ 09″	.985 162	.966 724	.189 709
33.5°	11° 08′ 08″	.985 074	.966 528	.190 250
33.6°	11° 10′ 07″	.984 985	.966 331	.190 790
33.7°	11° 12′ 06″	.984 896	.966 133	.191 330
33.8°	11° 14′ 05″	.984 807	.965 935	.191 870
33.9°	11° 16′ 04″	.984 717	.965 736	.192 410
34.0°	11° 18′ 03″	.984 627	.965 537	.192 949
34.1°	11° 20′ 02″	.984 537	.965 337	.193 488
34.2°	11° 22′ 01″	.984 447	.965 137	.194 027
34.3°	11° 24′ 00″	.984 356	.964 936	.194 566
34.4°	11° 25′ 59″	.984 265	.964 734	.195 104
34.5°	11° 27′ 58″	.984 174	.964 532	.195 643
34.6°	11° 29′ 57″	.984 083	.964 330	.196 180
34.7°	11° 31′ 56″	.983 991	.964 127	.196 718
34.8°	11° 33′ 55″	.983 899	.963 923	.197 256
34.9°	11° 35′ 54″	.983 807	.963 719	.197 793
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330
35.1°	11° 39′ 52″	.983 622	.963 309	.198 866
35.2°	11° 41′ 50″	.983 529	.963 103	.199 403
35.3°	11° 43′ 49″	.983 436	.962 897	.199 939
35.4°	11° 45′ 48″	.983 343	.962 690	.200 475
35.5°	11° 47′ 47″	.983 249	.962 483	.201 010
35.6°	11° 49′ 46″	.983 155	.962 275	.201 546
35.7°	11° 51′ 45″	.983 061	.962 066	.202 081
35.8°	11° 53′ 44″	.982 966	.961 857	.202 616
35.9°	11° 55′ 43″	.982 872	.961 648	.203 151
36.0°	11° 57′ 41″	.982 777	.961 438	.203 685
36.1°	11° 59′ 40″	.982 681	.961 227	.204 219
36.2°	12° 01′ 39″	.982 586	.961 016	.204 753
36.3°	12° 03′ 38″	.982 490	.960 804	.205 286
36.4°	12° 05′ 37″	.982 394	.960 592	.205 820
36.5°	12° 07′ 36″	.982 298	.960 379	.206 353
36.6°	12° 09′ 34″	.982 201	.960 165	.206 886
36.7°	12° 11′ 33″	.982 104	.959 951	.207 418
36.8°	12° 13′ 32″	.982 007	.959 737	.207 951
36.9°	12° 15′ 31″	.981 910	.959 522	.208 483
37.0°	12° 17′ 30″	.981 813	.959 306	.209 014
37.1°	12° 19′ 28″	.981 715	.959 090	.209 546
37.2°	12° 21′ 27″	.981 617	.958 874	.210 077
37.3°	12° 23′ 26″	.981 518	.958 657	.210 608
37.4°	12° 25′ 25″	.981 420	.958 439	.211 139
37.5°	12° 27′ 23″	.981 321	.958 221	.211 669
37.6°	12° 29′ 22″	.981 222	.958 002	.212 199
37.7°	12° 31′ 21″	.981 122	.957 783	.212 729
37.8°	12° 33′ 20″	.981 023	.957 563	.213 259
37.9°	12° 35′ 18″	.980 923	.957 342	.213 788
38.0°	12° 37′ 17″	.980 823	.957 121	.214 317
38.1°	12° 39′ 16″	.980 722	.956 900	.214 846
38.2°	12° 41′ 14″	.980 622	.956 678	.215 375
38.3°	12° 43′ 13″	.980 521	.956 456	.215 903
38.4°	12° 45′ 12″	.980 420	.956 232	.216 431
38.5°	12° 47′ 11″	.980 318	.956 009	.216 959
38.6°	12° 49′ 09″	.980 217	.955 785	.217 486
38.7°	12° 51′ 08″	.980 115	.955 560	.218 013
38.8°	12° 53′ 07″	.980 012	.955 335	.218 540
38.9°	12° 55′ 05″	.979 910	.955 109	.219 067
39.0°	12° 57′ 04″	.979 807	.954 883	.219 593
39.1°	12° 59′ 02″	.979 704	.954 656	.220 119
39.2°	13° 01′ 01″	.979 601	.954 429	.220 645
39.3°	13° 03′ 00″	.979 498	.954 201	.221 171
39.4°	13° 04′ 58″	.979 394	.953 973	.221 696
39.5°	13° 06′ 57″	.979 290	.953 744	.222 221
39.6°	13° 08′ 56″	.979 186	.953 514	.222 745
39.7°	13° 10′ 54″	.979 081	.953 284	.223 270
39.8°	13° 12′ 53″	.978 977	.953 054	.223 794
39.9°	13° 14′ 51″	.978 872	.952 823	.224 318
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841
40.1°	13° 18′ 48″	.978 661	.952 359	.225 365
40.2°	13° 20′ 47″	.978 555	.952 127	.225 888
40.3°	13° 22′ 46″	.978 449	.951 893	.226 410
40.4°	13° 24′ 44″	.978 343	.951 660	.226 933
40.5°	13° 26′ 43″	.978 236	.951 426	.227 455
40.6°	13° 28′ 41″	.978 130	.951 191	.227 977
40.7°	13° 30′ 40″	.978 023	.950 956	.228 498
40.8°	13° 32′ 38″	.977 915	.950 720	.229 019
40.9°	13° 34′ 37″	.977 808	.950 484	.229 540
41.0°	13° 36′ 35″	.977 700	.950 247	.230 061
41.1°	13° 38′ 34″	.977 592	.950 010	.230 581
41.2°	13° 40′ 32″	.977 484	.949 772	.231 102
41.3°	13° 42′ 31″	.977 375	.949 533	.231 621
41.4°	13° 44′ 29″	.977 266	.949 294	.232 141
41.5°	13° 46′ 28″	.977 157	.949 055	.232 660
41.6°	13° 48′ 26″	.977 048	.948 815	.233 179
41.7°	13° 50′ 25″	.976 938	.948 575	.233 698
41.8°	13° 52′ 23″	.976 828	.948 334	.234 216
41.9°	13° 54′ 22″	.976 718	.948 092	.234 734
42.0°	13° 56′ 20″	.976 608	.947 850	.235 252
42.1°	13° 58′ 18″	.976 498	.947 608	.235 769
42.2°	14° 00′ 17″	.976 387	.947 365	.236 286
42.3°	14° 02′ 15″	.976 276	.947 121	.236 803
42.4°	14° 04′ 14″	.976 164	.946 877	.237 320
42.5°	14° 06′ 12″	.976 053	.946 632	.237 836
42.6°	14° 08′ 10″	.975 941	.946 387	.238 352
42.7°	14° 10′ 09″	.975 829	.946 142	.238 868
42.8°	14° 12′ 07″	.975 716	.945 895	.239 383
42.9°	14° 14′ 06″	.975 604	.945 649	.239 898
43.0°	14° 16′ 04″	.975 491	.945 402	.240 413
43.1°	14° 18′ 02″	.975 378	.945 154	.240 927
43.2°	14° 20′ 01″	.975 264	.944 906	.241 442
43.3°	14° 21′ 59″	.975 151	.944 657	.241 956
43.4°	14° 23′ 57″	.975 037	.944 408	.242 469
43.5°	14° 25′ 56″	.974 923	.944 158	.242 982
43.6°	14° 27′ 54″	.974 808	.943 908	.243 495
43.7°	14° 29′ 52″	.974 694	.943 657	.244 008
43.8°	14° 31′ 50″	.974 579	.943 405	.244 520
43.9°	14° 33′ 49″	.974 464	.943 154	.245 032
44.0°	14° 35′ 47″	.974 348	.942 901	.245 544
44.1°	14° 37′ 45″	.974 232	.942 648	.246 055
44.2°	14° 39′ 44″	.974 117	.942 395	.246 567
44.3°	14° 41′ 42″	.974 001	.942 141	.247 077
44.4°	14° 43′ 40″	.973 884	.941 887	.247 588
44.5°	14° 45′ 38″	.973 768	.941 632	.248 098
44.6°	14° 47′ 37″	.973 651	.941 377	.248 608
44.7°	14° 49′ 35″	.973 534	.941 121	.249 117
44.8°	14° 51′ 33″	.973 416	.940 864	.249 627
44.9°	14° 53′ 31″	.973 299	.940 608	.250 135
45.0°	14° 55′ 29″	.973 181	.940 350	.250 644

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	$\frac{U}{L}$	$\frac{V}{L}$	Δ	$\frac{U}{L}$	$\frac{V}{L}$
0°	.666 667	.333 333	23°	.672 423	.338 586
1°	.666 678	.333 343	24°	.672 943	.339 061
2°	.666 710	.333 372	25°	.673 486	.339 559
3°	.666 763	.333 421	26°	.674 054	.340 078
4°	.666 838	.333 490	27°	.674 645	.340 619
5°	.666 935	.333 578	28°	.675 261	.341 183
6°	.667 053	.333 685	29°	.675 901	.341 769
7°	.667 193	.333 812	30°	.676 566	.342 378
8°	.667 354	.333 959	31°	.677 256	.343 011
9°	.667 537	.334 126	32°	.677 971	.343 667
10°	.667 742	.334 313	33°	.678 712	.344 346
11°	.667 968	.334 519	34°	.679 478	.345 050
12°	.668 216	.334 746	35°	.680 270	.345 777
13°	.668 487	.334 992	36°	.681 089	.346 529
14°	.668 779	.335 259	37°	.681 935	.347 307
15°	.669 094	.335 546	38°	.682 808	.348 109
16°	.669 431	.335 853	39°	.683 708	.348 937
17°	.669 790	.336 181	40°	.684 636	.349 791
18°	.670 172	.336 529	41°	.685 592	.350 671
19°	.670 576	.336 899	42°	.686 577	.351 578
20°	.671 003	.337 289	43°	.687 590	.352 513
21°	.671 453	.337 700	44°	.688 633	.353 474
22°	.671 926	.338 132	45°	.689 706	.354 464

*MAINTENANCE OF SURFACE.

(a) *Elevation of Curves, with special consideration as to amount and beginning and end of elevation, and as modified by location of curve and conditions of traffic:*

The approximate formula,

$$e = \frac{Gv^2}{32.16\,R}$$

in which $e =$ Elevation in feet,
$G =$ Gage of track in feet,
$v =$ Velocity in feet per second,
$R =$ Radius of curve in feet,

will give essentially correct theoretical elevation for the outer rail of curves, and is recommended for ordinary practice, but should be modified as noted below to suit special conditions.

For greater convenience the formula above may be further reduced by substituting

$$v = \frac{V\,5280}{3600},$$

$G = 4.708,$

$R = \frac{5730}{D}$ (approx.),

$e = 1\text{-}12\,E,$

in which $V =$ Velocity in miles per hour,
$D =$ Degree of curve,
and $E =$ Elevation of outer rail in inches at the gage line.
whence $E = .00066\,DV^2$.

This formula will give results which are expressed in the accompanying table:

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* Adopted, Vol. 3, 1902, pp. 56-59, 78-87; Vol. 5, 1904, pp. 528-533, 535, 562, 563; Vol. 6. 1905, pp. 754-757, 759-761; Vol. 11, 1910, pp. 935, 944; Vol. 12, 1911.

ELEVATION OF OUTER RAIL IN INCHES.

Degree of Curve.	Velocity in Miles per Hour.													Degree of Curve.
	10	15	20	25	30	35	40	45	50	55	60	65	70	
1	0	⅛	¼	⅜	⅝	¾	1⅛	1⅜	1⅝	2	2⅜	2¾	3¼	1
2	⅛	⅜	½	⅞	1⅛	1⅝	2⅛	2⅝	3¼	4	4¾	5½	6½	2
3	¼	½	¾	1¼	1¾	2⅜	3⅛	4	4⅞	6	7⅛	8⅜	9¾	3
4	¼	⅝	1	1⅝	2⅜	3¼	4¼	5⅜	6⅝	8	9½	......	......	4
5	⅜	¾	1¼	2	3	4	5¼	6⅝	8¼	......	......	......	......	5
6	⅜	1	1⅝	2½	3½	4⅞	6¼	8	......	......	......	......	......	6
7	½	1⅛	1⅞	2⅞	4⅛	5⅝	7⅜	......	......	......	......	......	......	7
8	½	1¼	2⅛	3¼	4¾	6½	8⅜	......	......	......	......	......	......	8
9	⅝	1⅜	2⅜	3¾	5⅜	7¼	......	......	......	......	......	......	......	9
10	¾	1½	2⅝	4⅛	5⅞	8⅛	......	......	......	......	......	......	......	10
11	¾	1¾	2⅞	4½	6½	8⅞	......	......	......	......	......	......	......	11
12	⅞	1⅞	3⅛	4⅞	7⅛	......	......	......	......	......	......	......	......	12
13	⅞	2	3⅜	5⅜	7¾	......	......	......	......	......	......	......	......	13
14	1	2⅛	3⅝	5¾	8⅜	......	......	......	......	......	......	......	......	14
15	1	2¼	3⅞	6¼	8⅞	......	......	......	......	......	......	......	......	15
16	1⅛	2½	4¼	6⅝	......	......	......	......	......	......	......	......	......	16
17	1¼	2⅝	4½	7	......	......	......	......	......	......	......	......	......	17
18	1¼	2¾	4¾	7½	......	......	......	......	......	......	......	......	......	18
19	1⅜	2⅞	5	7¾	......	......	......	......	......	......	......	......	......	19
20	1⅜	3	5¼	8⅛	......	......	......	......	......	......	......	......	......	20

Since the elevation required is a function of and depends upon the train speed, this speed is the first element to be determined.

In general, as a matter of safety, the preference should be given to fast passenger traffic.

Ordinarily an elevation of 8 in. should not be exceeded. Speed of trains should be regulated to conform to the maximum elevation used.

The elevation of curves should be zero at the point of spiral and should increase to full elevation at the end of the spiral or beginning of the simple curve.

The inner rail should be maintained at grade.

(b) *Vertical Curves:*

The use of vertical curves to connect changes in gradient is recommended.

The length should be determined by the gradients to be connected. On Class A roads rates of change of 0.1 per station on summits and 0.05 per station in sags should not be exceeded. On minor roads 0.2 per station on summits and 0.1 per station in sags may be used.

(c) *Proper Methods of Tamping:*

(1) *Earth or Clay Ballast:*

Tools: Shovel equipped with iron cuff or handle for tamping; broad pointed tamping bars.

Method: Tamp each tie from 18 in. inside of the rail to end of tie with handle of shovel or tamping bar. If possible, tamp the end of the tie outside of rail first and let train pass over before tamping inside of rail; give special attention to tamping under the rail; tamp center of ties loosely with the blade of the shovel; the dirt or clay between the ties should be placed in layers and firmly packed with feet or otherwise, so that it will quickly shed the water; the earth should not be banked above the bottom of the ends of the ties; the filling between the ties should not touch the rail and should be as high as, or higher than, the top of the ties in the middle of the track.

(2) *Cinder Ballast (Railroad Product):*

Tools: Shovel, tamping bar or tamping pick.

Method: Same as for gravel.

(3) *Burnt Clay Ballast:*

Tools: Shovel only in soft material. When burnt very hard, tamping pick or bar should be used.

Method: Tamp 15 in. inside of rail to end of tie, tamping end of tie first, letting train pass before tamping inside of rail; tamp center loosely; tamp well between the ties; dress ballast same as for earth or cinders.

(4) *Broken Stone or Furnace Slag:*

Tools: Shovel, tamping pick, stone forks.

Method: Tamp 15 in. inside of rail to end of tie; if possible, tamp the end of the tie outside of rail first and allow train to pass over before tamping inside of rail; tamp well under the rail; tamp well under ties from end of same; do not tamp center of tie; fill in between ties to height of top of tie; bank ballast into shoulder about the end of the ties level with top of tie.

(5) *Chats, Gravel or Chert Ballast:*

Tools: Shovels, tamping pick or tamping bar. For light traffic, shovel tamping is sufficient. For heavy traffic, the tamping pick or tamping bar should be used. The tamping bar is recommended instead of the tamping pick for ordinary practice.

Method: Tamp solid from a point 15 in. inside of rail to the end of the tie; if possible, tamp the end of the tie outside of the rail first and allow train to pass over before tamping inside of rail; care should be taken not to disturb the old bed. Tie should be tamped solidly from the end, using pick or tamping bar. After train has passed, the center of the tie should be loosely tamped with the blade of the shovel; dress same as stone ballast.

(6) *General:*

When not surfacing out of face, as in case of picking up low joints or other low places, the general level of the track should not be disturbed. Where the rails are out of level, but where the difference in elevation is not excessive and is uniform over long stretches of track, a difference in elevation between the two rails of ⅜-in. may be permitted to continue until such time as the track would ordinarily be surfaced out of face.

*MAINTENANCE OF GAGE.

(a) *Methods used to prevent spreading of track and canting of rails on curves:*

(1) Tie plates are recommended in all cases where economy in maintenance will result from their use.

(2) Shoulder tie plates are recommended in preference to rail braces, except for guard rails and stock rails at switches, where the latter should be used.

(3) For heavy traffic, shoulder tie plates should be used on all ties on curves.

(4) For medium traffic, shoulder tie plates should be used on all ties on curves over three degrees.

(5) For light traffic, the outside of rails on curves should be double spiked.

(6) The gage (tool) used should be the standard gage recommended.

(7) Within proper limits, a slight variation of gage from the standard is not seriously objectionable, provided the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regage track if the increase in gage has not amounted to more than one-half inch, providing such increase is uniform.

(8) Wide gage, due to worn rail, within the safe limits of wear, need not be corrected until the excess over the gage is equal to or exceeds one-half (½) in., and should then be corrected by closing in.

(9) Where track is intended to be spiked to standard gage, the rail should be held against the gage with a bar while the spike is being driven.

(10) Spikes should be started vertically and square, and so driven

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* Adopted, Vol. 5, 1904, pp. 534, 535, 563-569; Vol. 6, 1905, pp. 749, 750, 757, 759-761; Vol. 7, 1906, pp. 654, 664; Vol. 10, Part 1, 1909, pp. 398, 400, 467; Vol. 11, Part 2, 1910, pp. 934, 935, 944-946; Vol. 12, 1911.

that the face of the spike shall come in contact with the base of rail; the spike should never have to be straightened while being driven.

(11) The outside spikes of both rails should be on one side of the tie, and the inside spikes on the other. The inside and outside spikes should be spaced as far apart as the face and character of the tie will permit. The ordinary practice should be to drive the spike two and one-half (2½) in. from the outer edge of the tie. The old spike holes should be plugged.

*WIDTH OF STANDARD FLANGEWAY.

(1) The clear width of standard flangeway for all frogs and between main rails and guard rails should be 1¾ in., measured at the gage line, for all tracks of 4 ft. 8½ in. gage.

†WIDENING GAGE ON CURVES.

Curves eight degrees and under should be standard gage. Gage should be widened one-eighth inch for each two degrees or fraction thereof over eight degrees, to a maximum of 4 ft. 9¼ in. for tracks of standard gage. Gage, including widening due to wear, should never exceed 4 ft. 9½ in.

The installation of frogs upon the inside of curves is to be avoided wherever practicable, but where same is unavoidable, the above rule should be modified in order to make the gage of the track at the frog standard.

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* Adopted, Vol. 10, 1909, pp. 398, 466, 467.

† Adopted, Vol. 11, Part 2, 1910, pp. 942, 954, 955.

COMMITTEE VI.

BUILDINGS.

*WAITING ROOM IN LOCAL PASSENGER STATIONS.

The use of one general waiting room for a local passenger station (without reference to separate waiting rooms for colored people) is recommended as good practice for the following reasons:

(1) It permits the general waiting room to be properly proportioned.

(2) It permits proper development of a retiring room for women, with private entrance to the lavatory.

(3) It readily admits of the other rooms being properly proportioned.

(4) It permits ease of access from agent's office to the trains, to the baggage room and to the waiting room.

(5) It permits the ticket office to be used for registering or an "O.S"ing office.

(6) It admits of the station being contracted in size without detriment of facilities.

(7) It offers economy in heating.

†ENGINE HOUSE DESIGN.

(APPLICABLE TO NEW HOUSES AT IMPORTANT TERMINALS.)

(1) FORM.

(a) The circular form is preferable, with the following exceptions:

(b) At points where not more than three or four locomotives are housed at one time, and where it is more economical to provide a "Y" track than a turntable, or where it is not necessary to turn the locomotive,

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* Adopted, Vol. 6, 1905, pp. 682-684, 690; Vol. 11, Part 2, 1910, pp. 1022, 1023, 1049.

† Adopted, Vol. 6, 1905, pp. 684-686, 690-696; Vol. 7, 1906, pp. 630, 638; Vol. 10, Part 2, 1909, pp. 1123, 1124, 1132,-1136; Vol. 11, Part 2, 1910, pp. 1022. 1024-1026, 1049-1054.

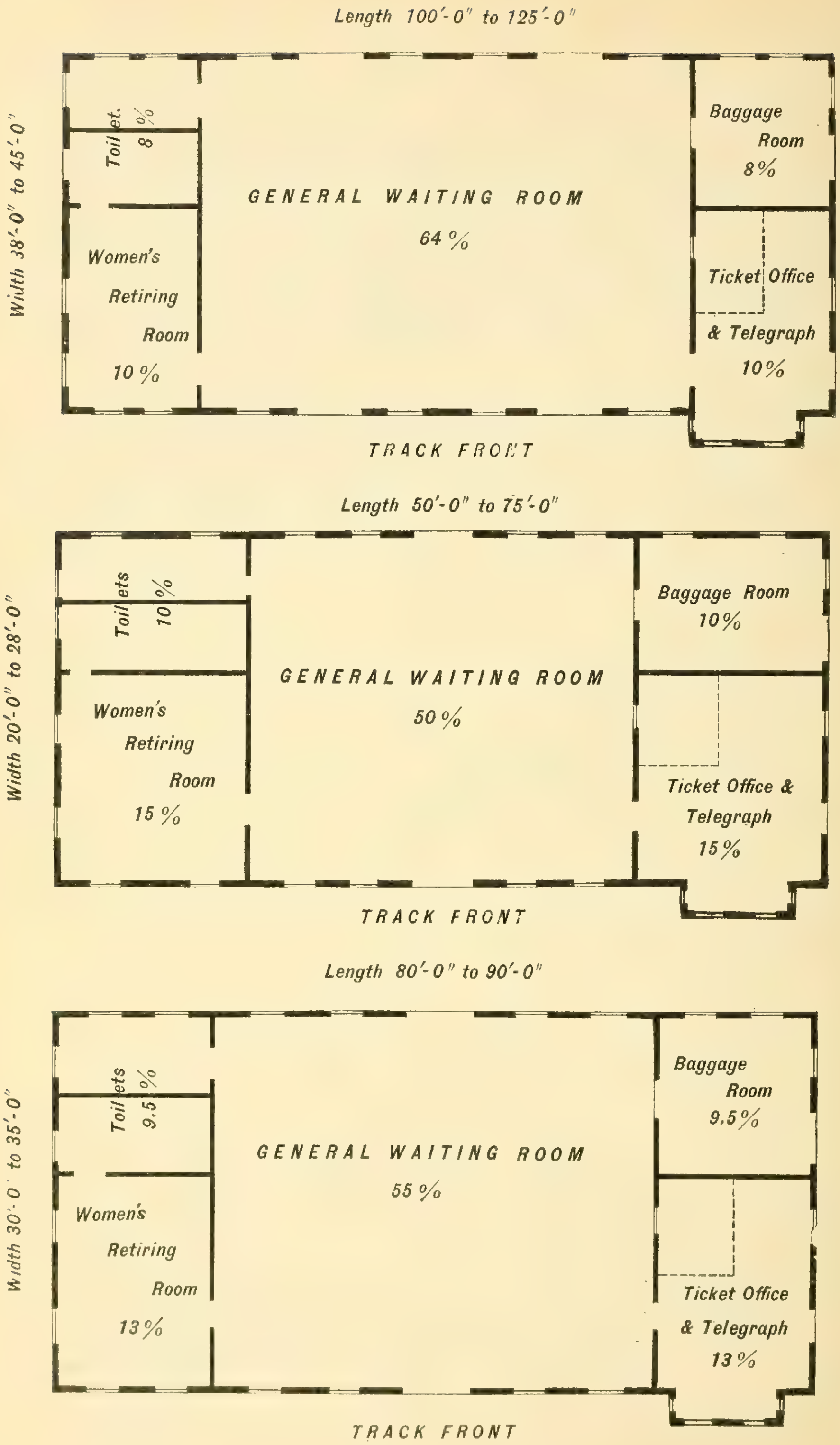
Length 100′-0″ to 125′-0″
Width 38′-0″ to 45′-0″
Toilet. 8 %
Women's Retiring Room 10 %
GENERAL WAITING ROOM 64 %
Baggage Room 8%
Ticket Office & Telegraph 10%
TRACK FRONT
Length 50′-0″ to 75′-0″
Width 20′-0″ to 28′-0″
Toilets 10 %
Women's Retiring Room 15 %
GENERAL WAITING ROOM 50 %
Baggage Room 10%
Ticket Office & Telegraph 15%
TRACK FRONT
Length 80′-0″ to 90′-0″
Width 30′-0″ to 35′-0″
Toilets 9.5 %
Women's Retiring Room 13 %
GENERAL WAITING ROOM 55 %
Baggage Room 9.5%
Ticket Office & Telegraph 13 %
TRACK FRONT

Fig. 1.

a rectangular house either with through tracks or with switches at one end only, may be desirable.

(c) At shops where a transfer table is used and an enginehouse is to be added, and at special locations, a transfer table house may be desirable.

(2) TURNTABLE.

(a) The turntable should be not less than seventy-five (75) ft. in length.

(b) The table may be operated economically by mechanical means.

(c) Where possible, the power should be transmitted through the pivot.

(3) TURNTABLE PIT.

The side walls of the turntable pit should be of concrete or brick with wooden coping not less than six (6) in. thick, and the ties under the circle rail should be supported on concrete.

(4) POSITION OF LOCOMOTIVE.

In a circular house the locomotive should stand normally with the tender toward the turntable.

(5) LENGTH.

The length of stall along center line of track should be not less than eighty-five (85) ft. in clear.

(6) DOOR OPENINGS.

The clear opening of entrance doors should be not less than .... (...) ft. in width and .... (...) ft. in height.

(7) ANGLE BETWEEN TRACKS.

The angle between the adjacent tracks should be an even factor of 180 degrees, so that the tracks at the opposite ends of the turntable will line up with it.

(8) MATERIALS.

(a) The material used in construction of the house should be non-corrosive, unless proper care be taken to prevent corrosion.

(b) Reinforced concrete should be used below the floor when it is cheaper than plain concrete.

(c) The additional security against interruption to traffic from fire warrants the serious consideration of the use of a reinforced concrete roof.

(d) When the roof is of reinforced concrete the columns and roof beams should be of the same material.

(e) Reinforced concrete should be used for the walls only where special conditions reduce its cost considerably below that of brick or plain concrete.

(9) DOORS.

Doors should be easily operated, fit snugly, be easily repaired and maintained, and should not be susceptible to damage by wind, directly or indirectly, and should admit of the use of small doors.

(10) ENGINE PITS.

Engine pits should be not less than 60 ft. in length, with convex floors, and with drainage toward the turntable. The walls and floors may be of concrete, and proper provision should be made for the support of the jacking timbers.

(11) SMOKE JACKS.

Smoke jacks should be fixed; the bottom opening should be not less than forty-two (42) in. wide, and long enough to receive the smoke from the stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The bottom of the jacks should be as low as the engines served will allow, and it should be furnished with a drip trough; the slope upward should be gradual to the flue; the area of the cross-section of the flue should be not less than seven (7) square feet, and the material used non-combustible.

(12) FLOORS.

The floor should be of permanent construction. It should be crowned between pits, and the part adjacent to pits within jacking limits should be of wood.

(13) DROP PITS.

Drop pits should be provided for handling truck wheels, driving wheels and trailer tender wheels.

(14) HEATING.

(a) Heat should be concentrated at the pits.

(b) The general temperature of the engine house should be kept between 50 and 60 degrees.

(c) The recommended method for heating is by hot air driven by fans through permanent ducts, which should be under the floor where practicable. The supply should be taken from the exterior of the building and no recirculation allowed. It should be delivered to the pits under the engine portion of the locomotive. It should be heated as far as may be by exhaust steam, supplemented as required by live steam.

(15) WINDOW LIGHTS.

(a) The disadvantages of roof lights are so much greater than their advantages as to make them undesirable.

(b) Windows in the outer walls should be made as large as practicable and contain the largest glass or light area consistent with the requisite strength. In general, the lower sill should be not more than four feet from the floor and only sufficient space left between pilasters and sides of window frames and girders and window heads to properly secure the window frames. Windows or transoms as large as practicable should be provided over all doors where locomotives enter, but where possible to avoid it window lights should not be placed in doors on account of difficulty of maintenance.

(16) ELECTRIC LIGHTING.

For general illumination there should be an arc lamp or something equally efficient in each space between stalls. There should also be plug outlets for incandescent lamps in each alternate space between stalls.

(17) PIPING.

(a) The contents of boilers should not be blown off into the house and engine pits, but by means of a blow-off pipe should be carried to a suitable receptacle and used for heating refilling and washout water. The refilling water and the washout water should be maintained at the same temperature in different parts of the house and under suitable pressure by means of pumps and return circulating lines. As necessary, the blow-off steam and water can be supplemented by steam from the power plant and additional water. The use of warm water for washing out and refilling considerably reduces the cost of boiler maintenance and the time necessary for a washout or change of water.

(b) Compressed air with from 80 to 100 lbs. pressure which can be used for operating air tools and also for hoists and blowing and steam with 100 lbs. pressure for use in raising boiler pressure should also be provided. The steam outlet is needed near the front end of the boiler and the incandescent light plugs; the blow-off pipe, the air, the washout and refilling water, and the cold water connections, should be near the front end of the firebox. Connections need only be provided in alternate spaces between stalls.

(18) TOOLS.

There should ordinarily be facilities for the location of a few machine tools, preferably electrically driven.

(19) HOISTS.

Air hoists or cranes with differential blocks should be provided for handling heavy repair parts.

(20) POWER PLANT.

Where circumstances permit, the efficiency of the power plant can be increased by using the locomotive water supply for condensing purposes.

*LOCOMOTIVE COALING STATIONS.

(1) In figuring the cost of handling coal, there should be included charges for interest and depreciation, charges for maintenance and operation (the cost of switching cars on to trestles should be included) and a charge for the use of the cars for storage purposes.

(2) Provision should be made for fire protection, the avoidance of damage to the coal, and its delivery in the best possible condition.

(3) The use of self-clearing cars should be made possible, and ordinarily it should also be possible to shovel from flat-bottomed cars.

(4) Storage for emergency purposes and fireproof construction are, in general, to be recommended, and in some cases duplicate machinery is desirable.

(5) It is not possible to give absolute limits between which different types of coaling arrangements are to be used. Each installation must be considered as an individual problem. Price of materials, cost and character of labor, the possible track arrangements, the amount of storage desired, the power and attendance and shifting service available, all are to be considered.

(a) Where the quantity of coal handled is small, particularly at terminal points where locomotives lie over night, it is recommended that the locomotives be coaled, either directly from cars or by handling from cars to an elevated platform provided with a jib crane and one-ton buckets, and from these buckets to the locomotive.

(b) At terminals, under certain conditions, a locomotive crane with suitable buckets is desirable, particularly where other work can be economically performed by the locomotive crane.

(c) At terminals, where the requirements do not exceed 200 tons a day, when the desired storage is not so great that auxiliary buckets are

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* Adopted, Vol. 8, 1907, pp. 268, 286; Vol. 9, 1908, pp. 163-166, 173, 183-200; Vol. 11, 1910, pp. 1027, 1054.

necessary, and where a deep foundation is practicable, a two-bucket hoist is recommended.

(d) For terminals larger than those previously described, the type of coaling station which should be selected as most desirable is dependent entirely upon local conditions. Where it is required that coal be delivered to not more than two tracks and where the necessary ground space is available, a coaling station of the trestle type, with incline approach, is recommended. In yards where delivering locomotives are constantly available, a plant with a 5 per cent. incline is preferable to one with a 20 per cent. grade operated by a hoisting engine. Where it is required to deliver coal at more than two tracks, or where the ground space for a trestle type is not available, a mechanical conveyor type is recommended.

*OIL HOUSES.

(1) Where practicable, oil houses at terminals should be isolated from the other buildings.

(2) Oil houses should be fireproof and the storage in large houses should preferably be either underground or in the basement.

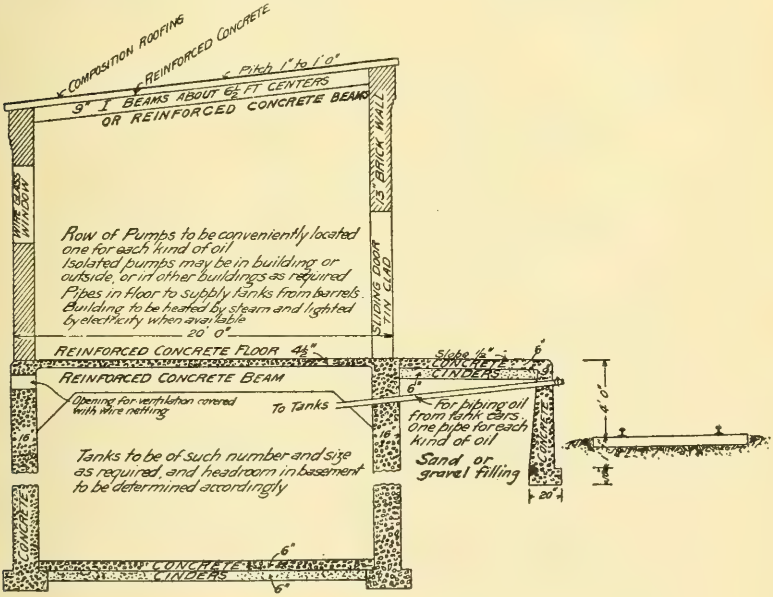
COMPOSITION ROOFING
REINFORCED CONCRETE
Pitch 1" to 1'0"
9" I BEAMS ABOUT 6½ FT CENTERS
OR REINFORCED CONCRETE BEAMS
WIRE GLASS WINDOW
13" BRICK WALL
Row of Pumps to be conveniently located one for each kind of oil
Isolated pumps may be in building or outside, or in other buildings as required
Pipes in floor to supply tanks from barrels.
Building to be heated by steam and lighted by electricity when available
20' 0"
SLIDING DOOR TIN CLAD
REINFORCED CONCRETE FLOOR 4½"
REINFORCED CONCRETE BEAM
Opening for ventilation covered with wire netting
To Tanks
16"
16"
Slope ½"
6"
CONCRETE
CINDERS
6"
For piping oil from tank cars. One pipe for each kind of oil
Sand or gravel filling
CONCRETE
20"
4' 0"
Tanks to be of such number and size as required, and headroom in basement to be determined accordingly
CONCRETE
6"
CONCRETE
CINDERS
6"

Fig. 2.—Cross-Section of Typical Oil House, 20x40 Ft.

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* Vol. 10, 1909, pp. 1127, 1128, 1136-1140; Vol. 11, Part 2, 1910, pp. 1027, 1037, 1054.

(3) Oils that are stored in sufficient quantities should be delivered to the tanks in the house direct from tank cars. For oils that are stored only in small quantities provision should be made for delivery to storage tanks from barrels by pipes through the floor.

(4) The delivery system from the storage tanks to the faucets should be such that the oil can be delivered quickly and measured automatically. The delivery should also be such that there will be a minimum of dripping at the faucet and that the dripping be drained back to the storage tanks.

(5) Openings for ventilation should be provided above the level of the top of the tanks.

(6) Lighting, when required, should be by electricity and heating by steam.

*SECTION TOOL HOUSE.

Class A:

House, 14x20 ft., with long dimension parallel to track; house to have sliding door 8 ft. in clear at extreme end on track side to permit the storing of hand car.

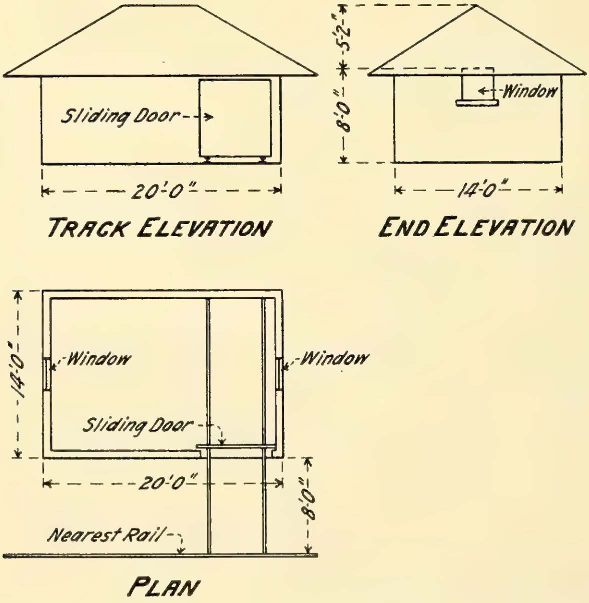
Sliding Door
20'-0"
TRACK ELEVATION
5'-2"
8'-0"
Window
14'-0"
END ELEVATION
14'-0"
Window
Window
Sliding Door
20'-0"
8'-0"
Nearest Rail
PLAN

Fig. 3.—Typical Section Tool House for Roads of Class A.

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* Adopted, Vol. 11, Part 2, 1911, pp. 1044-1046, 1054-1060.

Class B:

House, 12x18 ft., with long dimension parallel to the track; house to have sliding door 8 ft. in clear at extreme end on track side to permit the storing of handcar.

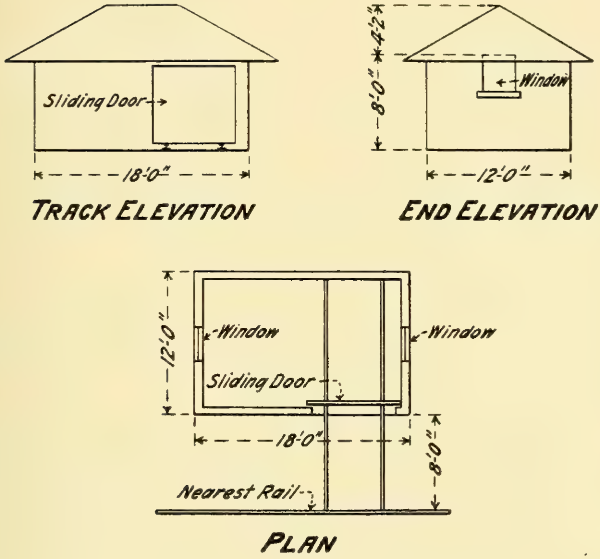
Sliding Door
18'-0"
TRACK ELEVATION
4'-2"
8'-0"
Window
12'-0"
END ELEVATION
12'-0"
Window
Window
Sliding Door
18'-0"
8'-0"
Nearest Rail
PLAN

FIG. 4.—TYPICAL SECTION TOOL HOUSE FOR ROADS OF CLASS B.

Class C:

House, 10x14 ft., with the short dimension parallel to the track, with double swinging door, swinging out on the end nearest the track.

Building to be on wooden posts, unless the location can be permanent, in which case brick or concrete piers may be substituted.

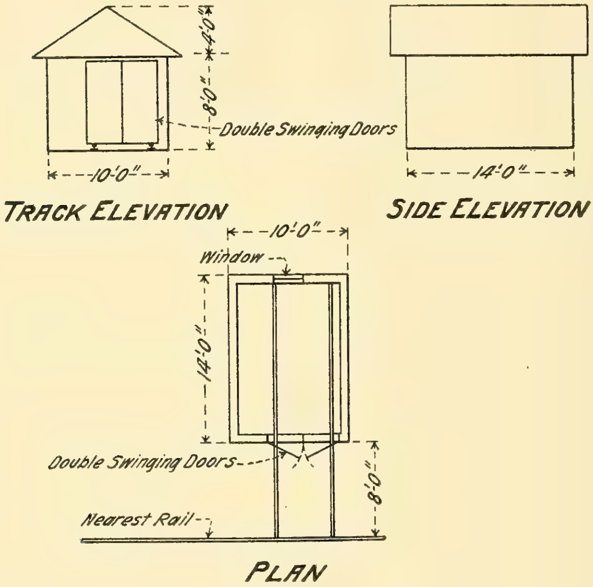
4'0"
8'0"
Double Swinging Doors
10'0"
14'0"
TRACK ELEVATION
SIDE ELEVATION
10'0"
Window
14'0"
Double Swinging Doors
8'0"
Nearest Rail
PLAN

Fig. 5.—Typical Section Tool House for Roads of Class C.

*ROOF COVERINGS.

The annoyance and indirect expense occasioned by leaky and short-lived roofs are rarely compensated for by any possible saving in first cost.

In selecting a roofing there should be considered:

(1) Chance of leaks due to character of construction.

(2) Probable life, including chance of damage by the elements and by wear from other causes.

(3) Fire-resisting value.

(4) Cost of maintenance.

(5) Cost of materials.

(6) Cost of laying.

The ordinary practice of depending merely upon guarantees in selecting roofings cannot be trusted to secure proper results.

Where proper materials and the requisite skill in application are available, built-up roofs of coal-tar felt, coal-tar pitch and gravel or slag are recommended for roofs with a pitch of two inches or less to the foot.

Where the roof is to be subjected to wear and where the character of the construction warrants the expense, flat tiles or brick should be used as a protective coating to the roofing instead of gravel or slag.

As a general proposition railroad building should be designed to accommodate this type to allow it to be used, and because of economy in construction and of decreased fire hazard. A pitch of from one-half to one inch to the foot is better than anything steeper. Nothing but straight-run pitch should be used.

No contracts should be made for a built-up roof without a complete and positive specification including flashings, and the contract prices should not be less than those of the materials specified, plus a reasonable amount to cover the cost of laying and profit. Thorough inspection of workmanship and material is recommended.

For slopes of from two to six inches to the foot fair results can be expected if the top coating of pitch be especially prepared. This can be successfully done only by skilled workmen, who are also necessary for its application. Especial care must also be taken in the selection and application of the stone or slag coating.

Asphaltic compounds have value for a built-up roof for the top coating or slopes of from two to six inches to the foot. They may also be

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* Adopted, Vol. 12, 1911.

desirable at points where good coal-tar cannot be obtained, except at a cost appreciably greater. They should not be used except where they can be obtained from reputable dealers with complete information as to their constituents and where they can be applied by men skilled in their use.

Ready or prepared roofings are recommended for use on small, temporary and other buildings, where the cost, considering maintenance, of more expensive buildings, is not justified. They are of value for steep slopes where a built-up coal-tar cannot be used, and for locations where the skilled labor necessary for a built-up roof is not available. The steeper the slope the greater their relative value and the wider their economical field. The heavier varieties are, in general, the more desirable because of their chance for longer life and their greater fire-resisting value. In making selections the reliability of the manufacturer, service tests and the cost should be governing factors.

In the laying of built-up and prepared roofings thoroughness in preparation of flashings and work around openings is of vital importance.

Slate and tile of suitable quality, properly protected and fastened, can be recommended on roofs with a pitch of six inches to the foot or over, where expense is not the governing feature, and where they aid in producing the desired architectural effect, except that where there is much chance of driving snow, eight inches to the foot should be the flattest slope allowed.

Wood shingles, except in isolated locations where there is small danger from sparks, should not be used.

Steel or impure iron materials should be avoided, no matter how protected.

COMMITTEE VII.

WOODEN BRIDGES AND TRESTLES.

* DEFINITIONS.

Wooden Trestle.—A wooden structure composed of upright members supporting simple horizontal members or beams, the whole forming a support for loads applied to the horizontal members.

Frame Trestle.—A structure in which the upright members or supports are framed timbers.

Pile Trestle.—A structure in which the upright members or supports are piles.

Bent.—The group of members forming a single vertical support of a trestle, designated as pile bent where the principal members are piles, and as framed bent where of framed timbers.

Post.—One of the vertical or battered members of the bent of a framed trestle.

Pile.—(See definition under subject of Piles and Pile Driving.)

Batter.—A deviation from the vertical in upright members of a bent.

Cap.—A horizontal member upon the top of piles or posts, connecting them in the form of a bent.

Sill.—A lower horizontal member of a framed bent.

Sub-Sill.—A timber bedded in the ground to support a framed bent.

Intermediate Sill.—A horizontal member in the plane of the bent between the cap and sill to which the posts are framed.

Sway Brace.—A member bolted or spiked to the bent and extending diagonally across its face.

Longitudinal Strut or Girt.—A stiff member running horizontally, or nearly so, from bent to bent.

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* Adopted, Vol. 6, 1905, pp. 35, 36, 42, 55-67; Vol. 7, 1906, pp. 683, 684; Vol. 11, Part 1, 1910, pp. 178, 228.

LONGITUDINAL X BRACE.—A member extending diagonally from bent to bent in a vertical or battered plane.

SASH BRACE.—A horizontal member secured to the posts or piles of a bent.

STRINGER.—A longitudinal member extending from bent to bent and supporting the ties.

JACK STRINGER.—A stringer placed outside of the line of main stringers.

TIE.—A transverse timber resting on the stringers and supporting the rails.

GUARD RAIL.—A longitudinal member, usually a metal rail, secured on top of the ties inside of the track rail, to guide derailed car wheels.

GUARD TIMBER.—A longitudinal timber framed over the ties outside of the track rail, to maintain the spacing of the ties.

PACKING BLOCK.—A small member, usually wood, used to secure the parts of a composite member in their proper relative positions.

PACKING SPOOL OR SEPARATOR.—A small casting used in connection with packing bolts to secure the several parts of a composite member in their proper relative positions.

DRIFT BOLT.—A piece of round or square iron of specified length, with or without head or point, driven as a spike.

DOWEL.—An iron or wooden pin, extending into, but not through, two members of the structure to connect them.

SHIM.—A small piece of wood or metal placed between two members of a structure to bring them to a desired relative position.

FISH-PLATE.—A short piece lapping a joint, secured to the side of two members, to connect them end to end.

BULKHEAD.—A wall of timber placed against the side of an end bent to retain the embankment.

* PILES AND PILE DRIVING.

PILE.—A member usually driven or jetted into the ground and deriving its support from the underlying strata, and by the friction of the ground on its surface.

The usual functions of a pile are: (*a*) To carry a superimposed load; *(b)* To compact the surrounding ground; *(c)* To form a wall to exclude water and soft material, or to resist the lateral pressure of adjacent ground.

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* Adopted, Vol. 10, 1909, p. 565.

HEAD OF PILE.—The upper end of a pile.

FOOT OF PILE.—The lower end of a pile.

BUTT OF PILE.—The larger end of a pile.

TIP OF PILE.—The smaller end of a pile.

BEARING PILE.—One used to carry a superimposed load.

SCREW PILE.—One having a broad-bladed screw attached to its foot to provide a larger bearing area.

DISC PILE.—One having a disc attached to its foot to provide a larger bearing area.

BATTER PILE.—One driven at an inclination to resist forces which are not vertical.

SHEET PILES.—Piles driven in close contact in order to provide a tight wall, to prevent leakage of water and soft materials, or driven to resist the lateral pressure of adjacent ground.

PILE DRIVER.—A machine for driving piles.

HAMMER.—A weight used to deliver blows to a pile to secure its penetration.

DROP HAMMER.—One which is raised by means of a rope and then allowed to drop.

STEAM HAMMER.—One which is automatically raised and dropped a comparatively short distance by the action of a steam cylinder and piston supported in a frame which follows the pile.

LEADS.—The upright parallel members of a pile driver which support the sheaves used to hoist the hammer and piles, and which guide the hammer in its movement.

CAP.—A block used to protect the head of a pile and to hold it in the leads during driving.

RING.—A metal hoop used to bind the head of a pile during driving.

SHOE.—A metal protection for the point or foot of a pile.

FOLLOWER.—A member interposed between the hammer and a pile to transmit blows to the latter when below the foot of the leads.

* STRUCTURAL TIMBER.

TIMBER.—A single stick of wood of regular cross-section.

CROSS-SECTION.—A section of a stick at right angles to the axis.

TRUE.—Of uniform cross-section. Defects are caused by wavy or jagged sawing or consist of trapezoidal instead of rectangular cross-sections.

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* Adopted, Vol. 11, Part 1, 1910, pp. 176, 178, 228.

Axis.—The line connecting the centers of successive cross-sections of a stick.

Straight.—Having a straight line for an axis.

Out of Wind.—Having the longitudinal surfaces plane.

Full Length.—Long enough to "square" up to the length specified in the order.

Corner.—The line of intersection of the planes of two adjacent longitudinal surfaces.

Girth.—The perimeter of a cross-section.

Side.—Either of the two wider longitudinal surfaces of a stick.

Edge.—Either of the two narrower longitudinal surfaces of a stick.

Face.—The surface of a stick which is exposed to view in the finished structure.

Sapwood.—A cylinder of wood next to the bark and of lighter color than the wood within. It may be of uneven thickness.

Heartwood.—The older and central part of a log, usually darker in color than sapwood. It appears in strong contrast to the sapwood in some species, while in others it is but slightly different in color.

Springwood.—The inner part of the annual ring formed in the earlier part of the season, not necessarily in the spring, and often containing vessels or pores.

Summerwood.—The outer part of the annual ring formed later in the season, not necessarily in the summer, being usually dense in structure and without conspicuous pores.

Decay.—Complete or partial disintegration of the cell walls, due to the growth of fungi.

Sound.—Free from decay.

Solid.—Without cavities; free from loose heart, wind shakes, bad checks, splits or breaks, loose slivers, and worm or insect holes.

Wane.—A deficient corner due to curvature or to taper of the log.

Square Cornered.—Free from wane.

Knot.—The hard mass of wood formed in a trunk at a branch, with the grain distinct and separate from the grain of the trunk.

Cross-Grain.—The gnarly mass of wood surrounding a knot, or grain injuriously out of parallel with the axis.

Wind Shake.—A crack or fissure, or a series of them, caused during growth.

*STANDARD DEFECTS OF STRUCTURAL TIMBER.

The standard defects included in the following list are mostly such as may be termed natural defects, as distinguished from defects of manufacture. The latter have usually been omitted, because the defects of manufacture are of minor significance in the grading of structural timber:

Sound Knot.—A sound knot is one which is solid across its face and is as hard as the wood surrounding it. It may be either red or black, and is so fixed by growth or position that it will retain its place in the piece.

Loose Knot.—A loose knot is one not firmly held in place by growth or position. (See Fig. 1.)

Pith Knot.—A pith knot is a sound knot with a pith hole not more than ¼ in. in diameter† in the center. (See Fig. 2.)

Encased Knot.—An encased knot is one which is surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ in. in width on each side, nor exceeding one-half the circumference of the knot, it shall be considered a sound knot. (See Fig. 3.)

Rotten Knot.—A rotten knot is one not as hard as the wood surrounding it. (See Fig. 4.)

Pin Knot.—A pin knot is a sound knot not over ½ in. in diameter. (See Fig. 5.)

Standard Knot.—A standard knot is a sound knot not over 1½ in. in diameter. (See Fig. 6.)

Large Knot.—A large knot is a sound knot, more than 1½ in. in diameter. (See Fig. 7.)

Round Knot.—A round knot is one which is oval or circular in form.

Spike Knot.—A spike knot is one sawn in a lengthwise direction. The mean or average diameter shall be taken as the size of these knots. (See Fig. 8.)

Pitch Pockets.—Pitch pockets are openings between the grain of the wood, containing more or less pitch or bark. These shall be classified as small, standard and large pitch pockets.

Small Pitch Pocket (a).—A small pitch pocket is one not over ⅛ in. wide. (See Fig. 9.)

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* Adopted, Vol. 8, 1907, pp. 401-408, 450-452; Vol. 9, 1908, pp. 316, 375, 376; Vol. 11, Part 1, 1910, pp. 178, 228.

† Measurements which refer to the diameter of knots or holes shall be considered as the mean or average diameter in all cases.

STANDARD PITCH POCKET (b).—A standard pitch pocket is one not over ⅜ in. wide nor over 3 in. in length.

LARGE PITCH POCKET (c).—A large pitch pocket is one over ⅜ in. wide, or over 3 in. in length.

PITCH STREAK.—A pitch streak is a well-defined accumulation of pitch at one point in the piece. When not sufficient to develop a well-defined streak, or where the fiber between grains, that is, the coarse grained fiber, usually termed "spring wood," is not saturated with pitch, it shall not be considered a defect. (See Fig. 10.)

SHAKES.—Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

RING SHAKE.—An opening between annual rings.

THROUGH SHAKE.—A shake which extends between two faces of a timber.

ROT, DOTE AND RED HEART.—Any form of decay which may be evident either as a dark red discoloration not found in the sound wood, or by the presence of white or red rotten spots, shall be considered as a defect.

WANE.—(See definition under the subject of Structural Timber.)

NOTE.—See additional definitions of defects under Structural Timber.

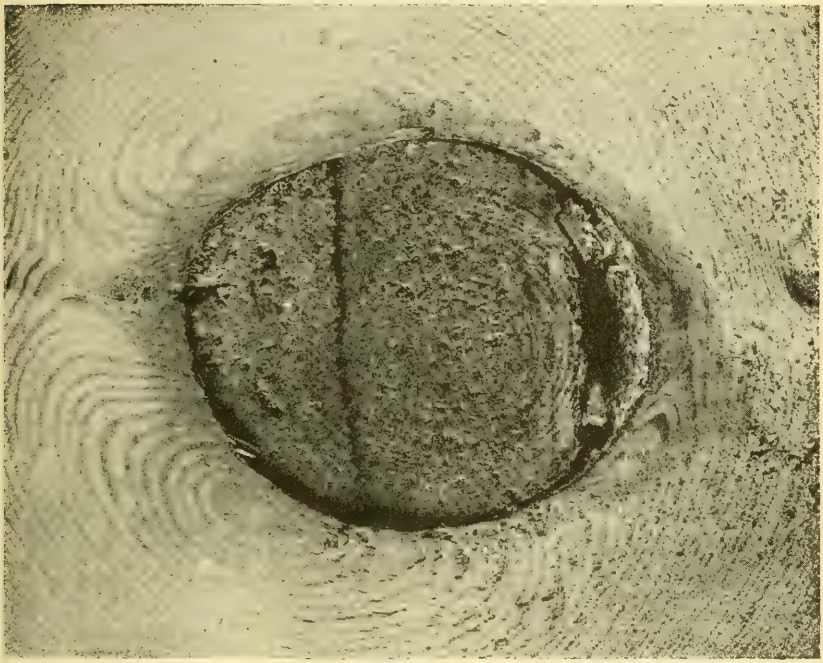

FIG. 1. LOOSE KNOT.

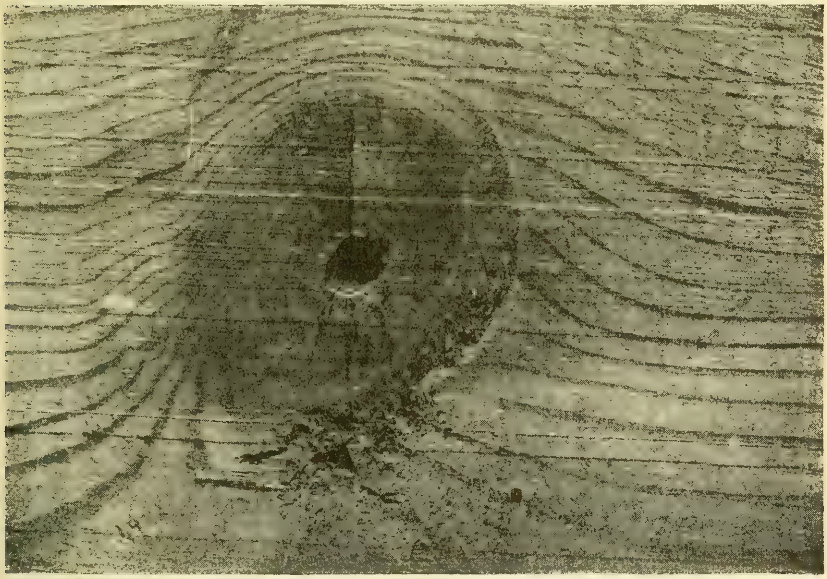

FIG. 2. PITH KNOT.

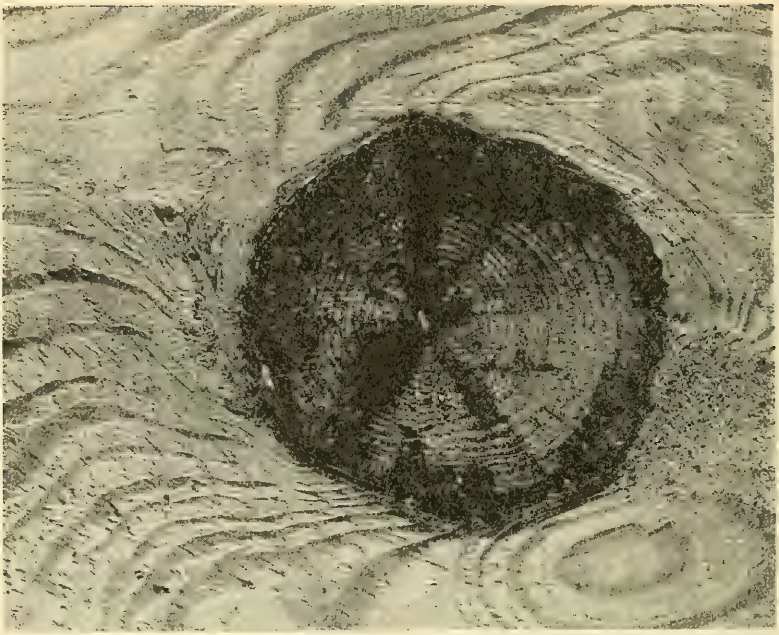

Fig. 3. Encased Knot.

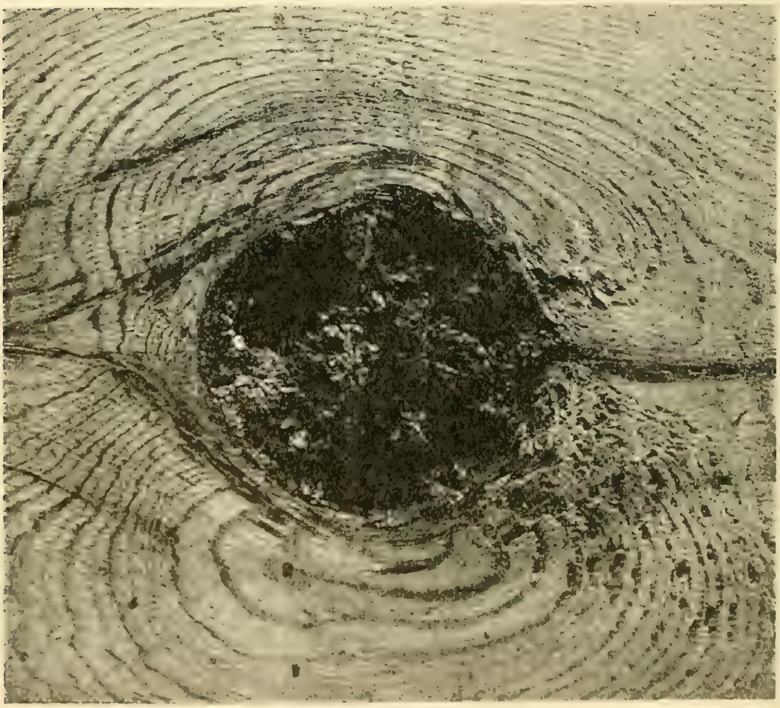

Fig. 4. Rotten Knot.

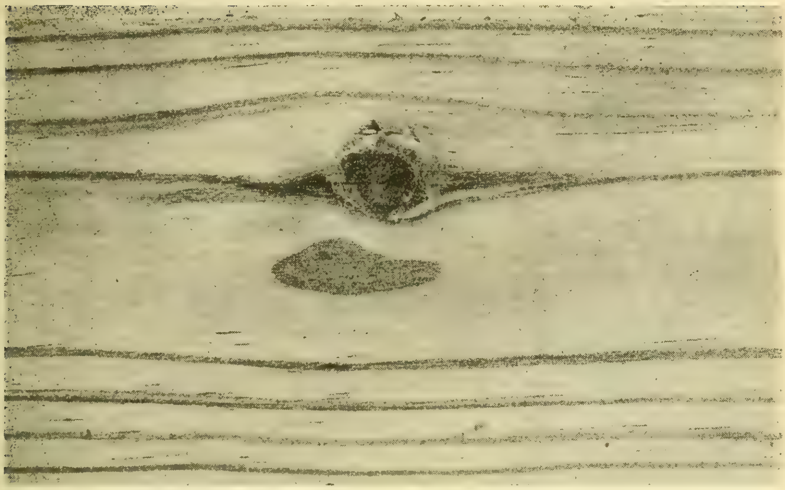

FIG. 5. PIN KNOT.

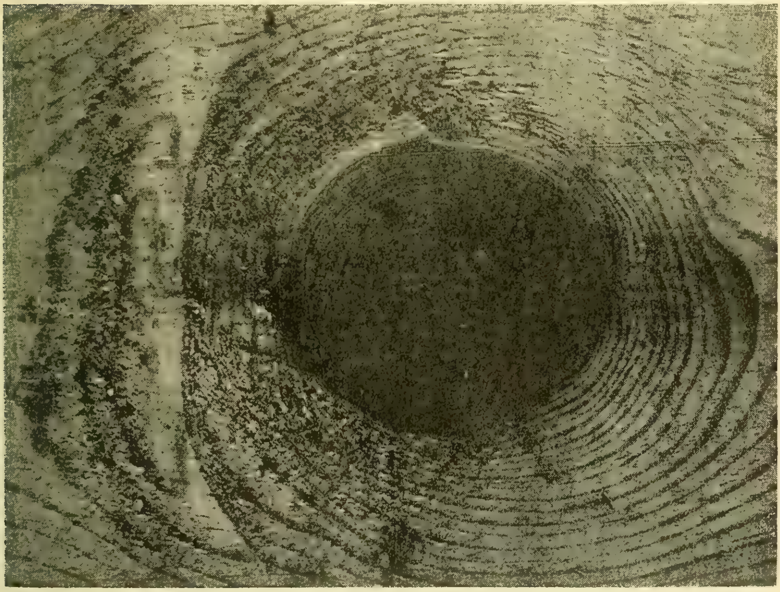

FIG. 6 STANDARD KNOT.

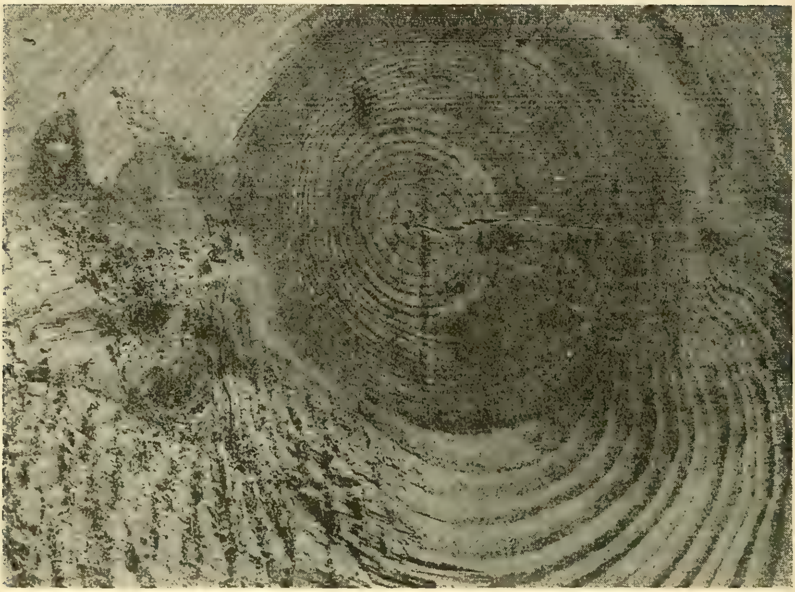

Fig. 7. Large Knot.

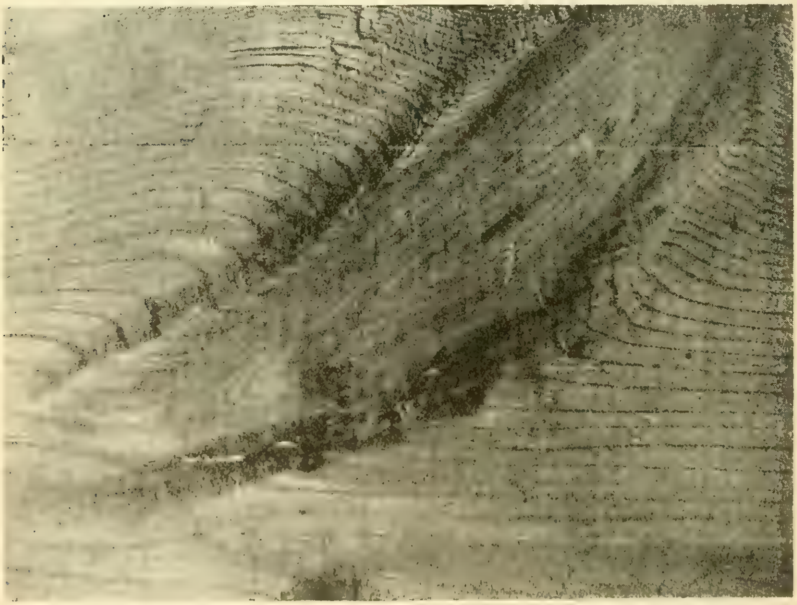

Fig. 8. Spike Knot.

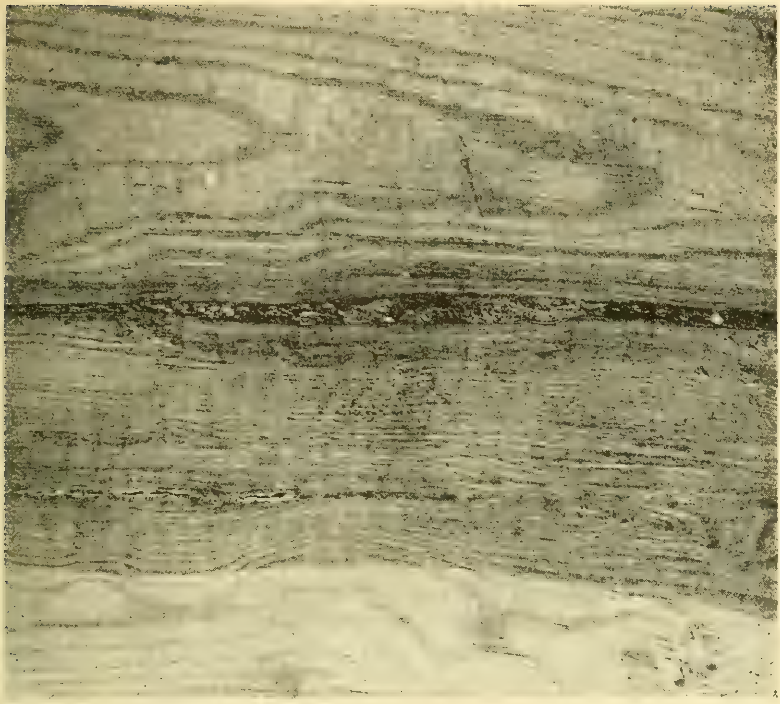

FIG. 9. SMALL PITCH. POCKET.

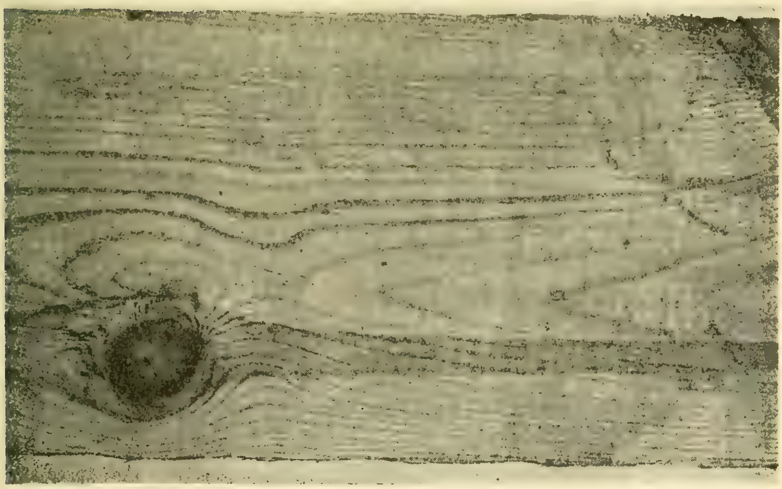

FIG. 10. PITCH STREAK.

*STANDARD NAMES FOR STRUCTURAL TIMBERS.

SOUTHERN YELLOW PINE.—Under this heading three classes of timber are used, (a) longleaf pine, (b) shortleaf pine, (c) loblolly pine.

DOUGLAS FIR.—The term "Douglas Fir" is to cover the timber known likewise as yellow fir, red fir, Western fir, Washington fir, Oregon or Puget Sound fir or pine, Northwest and West Coast fir.

NORWAY PINE, to cover what is known also as "Red Pine."

HEMLOCK, to cover Southern or Eastern hemlock; that is, hemlock from all States east of and including Minnesota.

WESTERN HEMLOCK, to cover hemlock from the Pacific Coast.

SPRUCE, to cover Eastern spruce; that is, the spruce timber coming from points east of Minnesota.

WESTERN SPRUCE, to cover spruce timber from the Pacific Coast.

WHITE PINE, to cover the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota.

IDAHO WHITE PINE, the variety of white pine from Western Montana, Northern Idaho, and Eastern Washington.

WESTERN PINE, to cover the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon and Washington. This is the timber sometimes known as "Western Yellow Pine," or "Ponderosa Pine," or "California White Pine," or "Western White Pine."

WESTERN LARCH, to cover the species of Larch or Tamarack from the Rocky Mountain and Pacific Coast regions.

TAMARACK, to cover the timber known as "Tamarack," or "Eastern Tamarack," from States east of and including Minnesota.

REDWOOD, to include the California wood usually known by that name.

OAK.—Under this heading three classes of timber are used, (a) White Oak, to include White Oak, Burr Oak and Post Oak. (b) Red Oak, to include Red Oak, Scarlet Oak, Black Oak; and all bastard oaks (c) Chestnut Oak, to include only Chestnut Oak.

†INSPECTION OF BRIDGE AND TRESTLE TIMBERS.

It is preferable to make the inspection of bridge and trestle timber at the mills.

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* Adopted, 1909, Vol. 10, p. 609.
† Adopted, 1909, Vol. 10, pp. 537, 541.

*STANDARD SPECIFICATIONS FOR SOUTHERN YELLOW PINE BRIDGE AND TRESTLE TIMBERS.

(To be applied to single sticks and not to composite members.)

GENERAL REQUIREMENTS.

General Requirements.

1. Except as noted, all timber shall be sound, sawed to standard size, full length, square cornered and straight; shall be close grained and free from defects such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay, or other defects that will materially impair its strength.

Standard Size.

2. Rough timbers sawed to standard size means that they shall not be over one-fourth (¼) in. scant from the actual size specified. For instance, a twelve by twelve (12x12) in. timber shall measure not less than eleven and three-fourths by eleven and three-fourths (11¾x11¾) in.

Standard Dressing.

3. Standard dressing means that not more than one-fourth (¼) in. shall be allowed for dressing each surface. For instance, a twelve by twelve (12x12) in. timber, after being dressed on four sides, shall measure not less than eleven and one-half by eleven and one-half (11½x11½) in.

STANDARD HEART GRADE, LONGLEAF YELLOW PINE.

Stringers.

4. Stringers shall show not less than eighty-five (85) per cent. heart on the girth anywhere in the length of the piece; provided, however, that if the maximum amount of sap is shown on either narrow face of the stringer, the average depth of sap shall not exceed one-half (½) in. Knots greater than one and one-half (1½) in. in diameter will not be permitted at any section within four (4) in. of the edge of the piece, but knots shall in no case exceed four (4) in. in their largest diameter.

Caps and Sills.

5. Caps and sills shall show not less than eighty-five (85) per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece; to be free from knots over two and one-half (2½) in. in diameter.

Posts.

6. Posts shall show not less than seventy-five (75) per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece, and to be free from knots over two and one-half (2½) in. in diameter.

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* Adopted, Vol. 10, Part 1, 1909, pp. 537, 539-541, 598-603; Vol. 11, 1910, Part 1, pp. 176, 180, 181, 228-230.

Longitudinal Struts and Girts.

7. Longitudinal Struts and Girts. One side shall show all heart; the other side shall show not less than eighty-five (85) per cent. heart, measured across the side anywhere in the length of the piece, and shall be free from any large knots or other defects that will materially injure its strength.

Longitudinal X Braces, Sash and Sway Braces.

8. Longitudinal X Braces, Sash Braces and Sway Braces shall show four square corners and not less than eighty (80) per cent. heart on each of two sides, and shall be free from any large knots or other defects that will materially injure their strength.

Ties and Guard Rails.

9. Ties and Guard Rails shall show one side all heart; the other side and two edges shall show not less than seventy-five (75) per cent. heart, measured across the surface anywhere in the length of the piece; shall be free from any large knots or other defects that will materially injure its strength; and where surfaced the remaining rough face shall show all heart.

STANDARD GRADE, LONGLEAF AND SHORTLEAF YELLOW PINE.

Stringers.

10. Stringers shall be square cornered, with the exception of one (1) in. wane on one corner or one-half (½) in. wane on two corners. Knots shall not exceed in their largest diameter one-fourth (¼) of the width of the surface of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

Caps and Sills.

11. Caps and Sills shall be square cornered, with the exception of one (1) in. wane on one corner, or one-half (½) in. wane on two corners. Knots shall not exceed in their largest diameter one-fourth (¼) of the width of the surface of the stick in which they occur, and in no case shall exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

Posts.

12. Posts shall be square cornered, with the exception of one (1) in. wane on one corner, or one-half (½) in. wane on two corners. Knots shall not exceed, in their largest diameter, one-fourth (¼) of the width of the surface of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

Longitudinal Struts or Girts.

13. Longitudinal Struts and Girts shall be square cornered and sound, and shall be free from any large knots or other defects that will materially injure their strength.

Longitudinal X Braces, Sash and Sway Braces.

14. Longitudinal X Braces, Sash Braces and Sway Braces shall be square cornered and sound, and shall be free from any large knots or other defects that will materially injure their strength.

EXPLANATORY NOTE FOR STANDARD HEART GRADE.

These specifications state the maximum limit of sap wood which will be accepted. In practice, with good inspection, the effect of these specifications should be to secure timber the bulk of which is practically all heart. In permanent bridge timber, not protected from decay, sap wood is not only useless in itself, but by furnishing a lodgment for the spores of fungi, it is the cause of starting and promoting the continuance of rot in the heart. Sap wood, especially after decay has set in, is also extremely susceptible to fire, while with precautions ordinarily exercised heart wood is practically immune from this source of danger.

On the other hand, for ordinary commercial purposes sap wood is as valuable as heart. Therefore, if the mill owners understand what is wanted, good heart timber can be obtained for a small advance in price over what is usually furnished, much of which contains in bulk 50 per cent. or more of sap wood.

To obtain proper results inspection should be made at the mills, where unsatisfactory timber can be rejected without hardship to the mill owner. Extensive buyers of timber should have inspectors stationed at the mills. To cover the needs of smaller buyers and municipalities, it seems that some of the established Inspection Companies might maintain an organization of timber inspectors at the mills, which would prove profitable to themselves, satisfactory to the mill owners and of incalculable benefit to those who use the timber.

* STANDARD SPECIFICATIONS FOR DOUGLAS FIR AND WESTERN HEMLOCK BRIDGE AND TRESTLE TIMBERS.

(To be applied to single sticks and not to composite members.)

STANDARD HEART GRADE.

1. Standard Heart Grade shall include yellow and red Douglas fir and Western hemlock. White Douglass fir will not be accepted. Standard Heart Grade.

2. General Requirements. All timber shall be live, sound, straight and close grained, cut square cornered, full length, not more than one-fourth (¼) in. scant in any dimension for rough timber or one-half (½) in. for dressed timber; free from large, loose or unsound knots, knots in groups, or other defects that will materially impair its strength for the purpose for which it is intended. Subject to inspection before loading. General Requirements.

3. Stringers shall show not less than ninety (90) per cent. heart on each side and edge, measured across the surface anywhere in the length of the piece. Shall be out of wind and free from shakes, splits, or pitch pockets over three-eighths (⅜) in. wide or five (5) in. long. Knots greater than two (2) in. in diameter will not be permitted within one-fourth (¼) of the depth of the stringer from any corner nor upon the edge of any piece; knots shall in no case exceed three (3) in. in diameter. Stringers.

4. Caps, Sills and Posts shall show not less than eighty-five (85) per cent. heart on each of the four sides, measured across the surface any- Caps, Sills and Posts.

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* Adopted, Vol. 11, Part 1, 1910, pp. 182, 183, 230-234.

where in the length of the piece. Shall be out of wind and free from shakes, splits, or pitch pockets over one-half (½) in. wide or five (5) in. long. Knots shall not exceed one-fourth (¼) of the width of the surface of the piece in which they occur and shall in no case exceed three (3) in. in diameter.

Longitudinal Struts or Girts, X Braces, Sash and Sway Braces.

5. Longitudinal Struts or Girts, X Braces, Sash and Sway Braces shall show one side all heart, the other side and two edges shall show not less than eighty-five (85) per cent. heart, measured across the surface anywhere in the length of the piece.

Ties and Guard Timbers.

6. Ties and Guard Timbers shall show one side and one edge all heart, the other side and edge shall show not less than eighty-five (85) per cent. heart, measured across the surface anywhere in the length of the piece.

Howe Truss Chords.

7. Timbers for Howe Truss Chords shall show not less than ninety (90) per cent. heart on each side and edge, measured anywhere in the length of the piece. Shall be out of wind and free from shakes, splits, or pitch pockets over one-eighth (⅛) in. wide or three (3) in. long. Knots shall not be over one and one-half (1½) in. in diameter nor be closer together on each surface than one in any four linear feet, but if knots are one (1) in. or less in diameter, one in any three linear feet will be allowed.

STANDARD GRADE.

Standard Grade.

8. Standard Grade shall include yellow, red and white Douglas fir and Western hemlock.

General Requirements.

9. General Requirements. All timbers shall be sound and cut square cornered, except that timbers ten by ten (10x10) in. in size may have a two (2) in. wane on one corner or its equivalent on two or more corners. Other sizes may have proportionate defects. Must be free from defects which will impair its utility for temporary work. Knots shall not exceed one-fourth (¼) the width of the surface of the piece in which they occur. Subject to inspection before loading.

Stringers, Caps, Sills and Posts.

10. Stringers, Caps, Sills and Posts shall be out of wind, free from shakes or splits extending over more than one-eighth (⅛) of the length of the piece, or knots more than four (4) in. in diameter. Knots greater than three (3) in. in diameter will not be permitted on the edge of any stringer.

* SPECIFICATIONS FOR TIMBER PILES.

RAILROAD HEART GRADE.

1. This grade includes white, burr, and post oak, longleaf pine, Douglas fir, tamarack, Eastern white and red cedar, chestnut, Western cedar, redwood and cypress.

2. Piles shall be cut from sound trees; shall be close grained and solid, free from defects, such as injurious ring shakes, large and unsound or loose knots, decay or other defects, which may materially impair their strength or durability. In Eastern red or white cedar a small amount of heart rot at the butt, which does not materially injure the strength of the pile, will be allowed.

3. Piles must be butt cut above the ground swell and have a uniform taper from butt to tip. Short bends will not be allowed. A line drawn from the center of the butt to the center of the tip shall lie within the body of the pile.

4. Unless otherwise allowed, piles must be cut when sap is down. Piles must be peeled soon after cutting. All knots shall be trimmed close to the body of the pile.

5. For round piles the minimum diameter at the tip shall be nine (9) in. for lengths not exceeding thirty (30) ft.; eight (8) in. for lengths over thirty (30) ft. but not exceeding fifty (50) ft., and seven (7) in. for lengths over fifty (50) ft. The minimum diameter at one-quarter of the length from the butt shall be twelve (12) in. and the maximum diameter at the butt twenty (20) in.

6. For square piles the minimum width of any side of the tip shall be nine (9) in. for lengths not exceeding thirty (30) ft.; eight (8) in. for lengths over thirty (30) ft. but not exceeding fifty (50) ft., and seven (7) in. for lengths over fifty (50) ft. The minimum width of any side at one-quarter of the length from the butt shall be twelve (12) in.

7. Square piles shall show at least eighty (80) per cent. heart on each side at any cross-section of the stick, and all round piles shall show at least ten and one-half (10½) in. diameter of heart at the butt.

RAILROAD FALSEWORK GRADE.

8. This grade includes red and all other oaks not included in R. R. Heart grade, sycamore, sweet, black and tupelo gum, maple, elm, hickory, Norway pine, or any sound timber that will stand driving.

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* Adopted, Vol. 10, 1909, pp. 537, 541, 542, 603-611.

9. The requirements for size of tip and butt, taper and lateral curvature are the same as for R. R. Heart grade.

10. Unless otherwise specified piles need not be peeled.

11. No limits are specified as to the diameter or proportion of heart.

12. Piles which meet the requirements of R. R. Heart grade except the proportion of heart specified will be classed as R. R. Falsework grade.

* SPECIFICATIONS FOR METAL DETAILS USED IN WOODEN BRIDGES AND TRESTLES.

GENERAL REQUIREMENTS.

Wrought-Iron.

1. Wrought-iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1 or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per sq. in., an elongation of 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent fibrous.

Steel.

2. Steel shall be made by the open-hearth process and shall be of uniform quality. It shall contain not more than 0.05 per cent. sulphur; if made by the acid process it shall contain not more than 0.06 per cent. phosphorus, and if made by the basic process not more than 0.04 per cent. phosphorus. When tested in specimens of the form of Fig. 1, or full-sized pieces of the same length, it shall have a desired ultimate tensile strength of 60,000 lbs. per sq. in. If the ultimate strength varies more than 4,000 lbs. from that desired, a retest shall be made on the same gage, which,

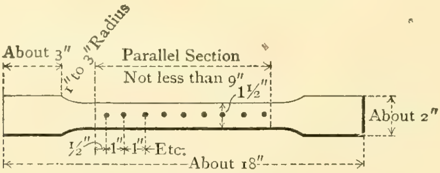

Fig. 1.

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* Adopted, Vol. 7, 1906, pp. 692-694, 719-724; Vol. 11, 1910.

to be acceptable, shall be within 5,000 lbs. of the desired ultimate. It shall have a minimum percentage of elongation in 8 in. of $\frac{1{,}500{,}000}{\text{ult. tens. strength}}$; and shall bend cold without fracture 180 degrees flat. The fracture for tensile tests shall be silky.

Cast-Iron. 3. Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ in. in diameter and 15 in. long. The transverse test shall be made on a supported length of 12 in., with load at middle. The minimum breaking load so applied shall be 2,900 lbs., with a deflection of at least 1/10 in. before rupture.

DETAIL SPECIFICATIONS.

Bolts. 4. Bolts shall be of wrought-iron or steel, made with square heads, standard size, the length of thread to be 2½ times the diameter of bolt. The nuts shall be made square, standard size, with thread fitting closely the thread of bolt. Threads shall be cut according to U. S. standards.

Drift Bolts. 5. Drift bolts shall be of wrought-iron or steel, with or without square head, pointed or without point, as may be called for on the plans.

Spikes. 6. Spikes shall be of wrought-iron or steel, square or round, as called for on the plans; steel wire spikes, when used for spiking planking, shall not be used in lengths more than 6 in.; if greater lengths are required, wrought or steel spikes shall be used.

Packing Spools or Separators. 7. Packing spools or separators shall be of cast-iron, made to size and shape called for on plans; the diameter of hole shall be ⅛ in. larger than diameter of packing bolts.

Cast Washers. 8. Cast washers shall be of cast-iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and its thickness equal to the diameter of bolt; the diameter of hole shall be ⅛ in. larger than the diameter of the bolt.

Wrought Washers. 9. Wrought washers shall be of wrought-iron or steel, the diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ¼ in. thick. The hole shall be ⅛ in. larger than the diameter of the bolt.

Special Castings. 10. Special castings shall be made true to pattern, without wind, free from flaws and excessive shrinkage; size and shape to be as called for by the plans.

*SPECIFICATIONS FOR WORKMANSHIP FOR PILE AND FRAME TRESTLES TO BE BUILT UNDER CONTRACT.

SITE.

1. The trestle to be built under these specifications is located on the line of .... Railroad at .... County of .... State of ....

GENERAL DESCRIPTION.

2. The work to be done under these specifications covers the driving, framing and erection of a .... track wooden trestle about .... ft. long and an average of .... ft. high.

GENERAL CLAUSES.

3. The contractor shall furnish all necessary labor, tools, machinery, supplies, temporary staging and outfit required. He shall build the complete trestle ready for the track rails, in a workmanlike manner, in strict accordance with the plans and the true intent of these specifications, to the satisfaction and acceptance of the engineer of the railroad company.

4. The workmanship shall be of the best quality in each class of work. Details, fastenings and connections shall be of the best method of construction in general use on first-class work.

5. Holes shall be bored for all bolts. The depth of the hole and the diameter of the auger to be as specified by the engineer.

6. Framing shall be accurately fitted; no blocking or shimming will be allowed in making joints. Timbers shall be cut off with the saw; no axe to be used.

7. Joints and points of bearing, for which no fastening is shown on the plans, shall be fastened as specified by the engineer.

8. The engineer or his authorized agents shall have full power to cause any inferior work to be condemned, and taken down or altered, at the expense of the contractor. Any material destroyed by the contractor on account of inferior workmanship or carelessness of his men is to be replaced by the contractor at his own expense.

9. Figures shown on the plans shall govern in preference to scale measurements; if any discrepancies should arise or irregularities be discovered in the plans, the contractor shall call on the engineer for

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* Adopted, Vol. 8, 1907, pp. 397-400, 442-450.

instructions. These specifications and the plans are intended to co-operate, and if any question arises as to the proper interpretation of the plans or specifications, it shall be referred to the engineer for a ruling.

10. The contractor shall, when required by the engineer, furnish a satisfactory watchman to guard the work.

11. On the completion of the work, all refuse material and rubbish that may have accumulated on top or under and near the trestle, by reason of its construction, shall be removed by the contractor.

DETAIL SPECIFICATIONS.

12. Piles shall be carefully selected to suit the place and ground where they are to be driven. When required by the engineer, pile butts shall be banded with iron or steel for driving, and the tips with suitable iron or steel shoes; such shoes will be furnished by the railroad company.

13. Piles shall be driven to a firm bearing, satisfactory to the engineer, or until five blows of a hammer weighing 3,000 lbs., falling 15 feet (or a hammer and fall producing the same mechanical effect), are required to cause an average penetration of one-half (½) in. per blow, except in soft bottom, where special instructions will be given.

14. Batter piles shall be driven to the inclination shown by the plans, and shall require but slight bending before framing.

15. Butts of all piles in a bent shall be sawed off to one plane and trimmed so as not to leave any horizontal projection outside of the cap.

16. Piles injured in driving, or driven out of place, shall either be pulled out or cut off, and replaced by new piles.

Caps. 17. Caps shall be sized over the piles or posts to a uniform thickness and even bearing on piles or posts. The side with most sap shall be placed downward.

Posts. 18. Posts shall be sawed to proper length for their position (vertical or batter), and to an even bearing on cap and sill.

Sills. 19. Sills shall be sized at the bearing of posts to one plane.

Sway Braces. 20. Sway bracing shall be properly framed and securely fastened to piles or posts. When necessary for pile bents, filling pieces shall be used between the braces and the piles on account of the variation in size of piles, and securely fastened and faced to obtain a bearing against all piles.

Longitudinal Braces. 21. Longitudinal X-braces shall be properly framed and securely fastened to piles or posts.

Girts. 22. Girts shall be properly framed and securely fastened to caps, sub-sills, posts or piles, as the plans may require.

Stringers. 23. Stringers shall be sized to a uniform height at supports. The edges with most sap shall be placed downward.

Jack Stringers. 24. Jack stringers, if required on the plans, shall be neatly framed on caps, and their tops shall be in the same plane as the track stringers.

Ties. 25. Ties shall be framed to a uniform thickness over bearings, and shall be placed with the rough side upward. They shall be spaced regularly, cut to even length and line, as called for on the plans.

Guard Rails. 26. Timber guard rails shall be framed as called for on the plans, laid to line and to a uniform top surface. They shall be firmly fastened to the ties as required.

Bulkheads. 27. Bulkheads shall be of sufficient dimensions to keep the embankment clear of the caps, stringers and ties, at the end bents of the trestle. There shall be a space of not less than two (2) in. between the back of the end bent and the face of the bulkhead. The projecting ends of the bulkhead shall be sawed off to conform to the slope of the embankment, unless otherwise specified.

Time of Completion. 28. The work shall be completed in all its parts on or before .... A. D. 19......

Payments. 29. Payments will be made under the usual regulations of the railroad company.

*PILE-DRIVING—PRINCIPLES OF PRACTICE.

(1) A thorough exploration of the soil by borings, or preliminary test piles, is the most important prerequisite to the design and construction of pile foundations.

(2) The cost of exploration is frequently less than that otherwise required merely to revise the plans of the structures involved, without considering the unnecessary cost of the structures due to lack of information.

(3) Where adequate exploration is omitted, it may result in the entire loss of the structure, or in greatly increased cost.

(4) The proper diameter and length of pile, and the method of driving, depend upon the result of the previous exploration and the purpose for which they are intended.

(5) Where the soil consists wholly or chiefly of sand, the conditions are most favorable to the use of the water jet.

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*Adopted, Vol. 12, 1911.

(6) In harder soils containing gravel the use of the jet may be advantageous, provided sufficient volume and pressure be provided.

(7) In clay it may be economical to bore several holes in the soil with the aid of the jet before driving the pile, thus securing the accurate location of the pile, and its lubrication while being driven.

(8) In general, the water jet should not be attached to the pile, but handled separately.

(9) Two jets will often succeed where one fails; in special cases a third jet extending a part of the depth aids materially in keeping loose the material around the pile.

(10) Where the material is of such a porous character that the water from the jets may be dissipated and fail to come up in the immediate vicinity of the pile, the utility of the jet is uncertain, except for a part of the penetration.

(11) A steam or drop hammer should be used in connection with the water jet, and used to test the final rate of penetration.

(12) The use of the water jet is one of the most effective means of avoiding injury to piles by overdriving.

(13) There is danger from overdriving when the hammer begins to bounce. Overdriving is also indicated by the bending, kicking or staggering of the pile.

(14) The brooming of the head of a pile dissipates a part, and in some cases all, of the energy due to the fall of the hammer.

(15) The weight or the drop of the hammer should be proportioned to the weight of the pile, as well as to the character of the soil to be penetrated.

(16) The steam hammer is more effective than the drop hammer in securing the penetration of a pile without injury, because of the shorter interval between blows.

(17) Where shock to surrounding material is apt to prove detrimental to the structure, the steam hammer should always be used instead of the drop hammer. This is especially true in the case of sheet piling which is intended to prevent the passage of water. In some cases also the jet should not be used.

(18) In general, the resistance of piles, penetrating soft material, which depend solely upon skin friction, is materially increased after a period of rest. This period may be as short as fifteen minutes, and rarely exceeds twelve hours.

(19) In tidal waters the resistance of a pile driven at low tide is increased at high tide on account of the extra compression of the soil.

(20) Where a pile penetrates muck or a soft yielding material and bears upon a hard stratum at its foot, its strength should be determined as a column or beam; omitting the resistance, if any, due to skin friction.

(21) Unless the record of previous experience at the same site is available, the approximate bearing power may be obtained by loading test piles. The results of loading test piles should be used with caution, unless their condition is fairly comparable with that of the piles in the proposed foundation.

(22) In case the piles in a foundation are expected to act as columns the results of loading test piles should not be depended upon unless they are sufficient in number to insure their action in a similar manner, and they are stayed against lateral motion.

(23) Before testing the penetration of a pile in soft material where its bearing power depends principally, or wholly, upon skin friction, the pile should be allowed to rest for 24 hours after driving.

(24) Where the resistance of piles depends mainly upon skin friction it is possible to diminish the combined strength, or bearing capacity, of a group of piles by driving additional piles within the same area.

(25) Where there is a hard stratum overlying softer material through which the piles are to pass to a firm bearing below, the upper stratum should be removed by dredging or otherwise, provided it would injure the piles to drive through the stratum. The material removed may be replaced if it is needed to provide lateral resistance.

(26) Timber piles may be advantageously pointed, in some cases, to a 4-in. or 6-in. square at the end.

(27) Piles should not be pointed when driven into soft material.

(28) Shoes should be provided for piles when the driving is very hard, especially in riprap or shale, and should be so constructed as to form an integral part of the pile.

(29) The use of a cap is advantageous in distributing the impact of the hammer more uniformly over the head of the pile, as well as to hold it in position during driving.

(30) The specification relating to the penetration of a pile should be adapted to the soil which the pile is to penetrate.

(31) It is far more important that a proper length of pile should be put in place without injury than that its penetration should be a specified distance under a given blow, or series of blows.

*WORKING UNIT-STRESSES FOR STRUCTURAL TIMBER EXPRESSED IN POUNDS PER SQUARE INCH.

NOTE.—The working unit-stresses given in this table are intended for railroad bridges and trestles. For highway bridges and trestles the unit-stresses may be increased twenty-five (25) per cent. For buildings and similar structures, in which the timber is protected from the weather and practically free from impact, the unit-stresses may be increased fifty (50) per cent. To compute the deflection of a beam under long-continued loading instead of that when the load is first applied, only fifty (50) per cent of the corresponding modulus of elasticity given in the table is to be employed.

KIND OF TIMBER.	BENDING.			SHEARING.				COMPRESSION.						Ratio of Length of Stringer to Depth.
	Extreme Fiber Stress.		Modulus of Elasticity.	Parallel to the Grain.		Longitudinal Shear in Beams.		Perpendicular to the Grain.		Parallel to the Grain.		For Columns under 15 Diams. Working Stress.	Formulas for Working Stress in Long Columns over 15 Diameters.	
	Average Ultimate	Working Stress	Average	Average Ultimate	Working Stress	Average Ultimate	Working Stress	Elastic Limit	Working Stress	Average Ultimate	Working Stress			
Douglas Fir	6100	1200	1 510 000	690	170	270	110	630	310	3600	1200	900	$1200(1-l/60d)$	10
Longleaf Pine	6500	1300	1 610 000	720	180	300	120	520	260	3800	1300	980	$1300(1-l/60d)$	10
Shortleaf Pine	5600	1100	1 480 000	710	170	330	130	340	170	3400	1100	830	$1100(1-l/60d)$	10
White Pine	4400	900	1 130 000	400	100	180	70	290	150	3000	1000	750	$1000(1-l/60d)$	10
Spruce	4800	1000	1 310 000	600	150	170	70	370	180	3200	1100	830	$1100(1-l/60d)$	
Norway Pine	4200	800	1 190 000	590*	130	250	100	—	150	2600*	800	600	$800(1-l/60d)$	
Tamarack	4600	900	1 220 000	670	170	260	100	—	220	3200*	1000	750	$1000(1-l/60d)$	
Western Hemlock	5800	1100	1 480 000	630	160	270*	100	440	220	3500	1200	900	$1200(1-l/60d)$	
Redwood	5000	900	800 000	300	80	—	—	400	150	3300	900	680	$900(1-l/60d)$	
Bald Cypress	4800	900	1 150 000	500	120	—	—	340	170	3900	1100	830	$1100(1-l/60d)$	
Red Cedar	4200	800	800 000	—	—	—	—	470	230	2800	900	680	$900(1-l/60d)$	
White Oak	5700	1100	1 150 000	840	210	270	110	920	450	3500	1300	980	$1300(1-l/60d)$	12

These unit-stresses are for a green condition of timber and are to be used without increasing the live load stresses for impact.

*Partially air-dry.

l = Length in inches.
d = Least side in inches.

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* Adopted, Vol. 10, 1909, pp. 537, 564, 609-611.

Size 8x13 inches. Form M. W. 701.

*PILE RECORD FORM.

A. B. & C. R. R. Co.

Pile Record of Bridge..

LOCATION..

Weight and Kind of Hammer.......................................**Date**.....................19......

Bents Numbered from North or East End **Piles numbered from Left to Right**

Date	Bent No.	No. of Pile	Size of Pile			Kind of Wood	Cut-off	Base-rail to Ground	Total Penetrat.	Av. Last Five Blows		Kind of Soil	Remarks
			Tip End	Butt End	Length					Drop of Ham'r	Penetrat.		

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*Adopted, Vol. 12, Part 1, 1911.

COMMITTEE VIII.

MASONRY.

*CLASSIFICATION OF MASONRY.

KIND.	Material.	Description.	Manner of Work.	Dressing.	
				Joints or Beds.	Face or Surface.
Bridge and Retaining Wall.	Stone	Dimension	Coursed	Smooth	Smooth Rock-faced
		Ashlar	Coursed Broken-coursed	Smooth Fine pointed Rough p'ted	Smooth Rock-faced
		Rubble	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain Rubble			
Arch...........	Stone	Ashlar	Coursed	Smooth Fine pointed	Smooth Rock-faced
		Rubble	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain			
	Brick	No. 1	English Bond Flemish Bond		
Culvert........	Stone	Rubble Dry	Uncoursed	Rough p'ted Scabbled	Rock-faced
	Concrete	Reinforced Plain Rubble			
Dry...........	Stone	Rubble	Uncoursed		

*DEFINITIONS.

Masonry, Bridge and Retaining Wall.—Masonry of stone or concrete, designed to carry the end of a bridge span or to retain the abutting earth, or both.

Masonry, Arch.—That portion of the masonry in the arch ring only, or between the intrados and the extrados.

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* Adopted, Vol. 7, 1906, pp. 596-601, 619; Vol. 12, 1911.

Masonry, Culvert.—Flat-top masonry structure of stone or concrete, designed to sustain the fill above and to permit of the free passage of water.

Masonry, Dry.—Masonry in which stones are built up without the use of mortar.

CONCRETE.

Concrete.—A compact mass of broken stone, gravel or other suitable material assembled together with cement mortar and allowed to harden.

Reinforced Concrete.—Concrete which has been reinforced by means of metal in some form, so as to develop the compressive strength of the concrete.

Rubble Concrete.—Concrete in which rubble stone are imbedded.

BRICK.

Brick.—No. 1.—Hard burned brick, absorption not exceeding 2 per cent. by weight.

CEMENT.

Cement.—A material of one of the three classes, Portland, Natural and Puzzolan, possessing the property of hardening into a solid mass when mixed with water.

Portland Cement.—This term shall be applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent. has been made subsequent to calcination.

Natural Cement.—This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Puzzolan Cement, as Made in North America.—An intimate mixture obtained by finely pulverizing together granulated basic blast furnace slag and slacked lime.

COURSES AND BOND.

Coursed.—Laid with continuous bed joints.

Broken Coursed.—Laid with parallel, but not continuous, bed joints.

Uncoursed.—Laid without regard to courses.

English Bond.—That disposition of bricks in a structure in which each course is composed entirely of headers or of stretchers.

Flemish Bond.—That disposition of bricks in a structure in which the headers and stretchers alternate in each course, the header being so placed that the outer end lies on the middle of a stretcher in the course below.

DRESSING.

Dressing.—The finish given to the surface of stones or to concrete.

Smooth.—Having surface, the variations of which do not exceed one-sixteenth inch from the pitch line.

Fine Pointed.—Having irregular surface, the variations of which do not exceed one-quarter inch from the pitch line.

Rough Pointed.—Having irregular surface, the variations of which do not exceed one-half inch from the pitch line.

Scabbled.—Having irregular surface, the variations of which do not exceed three-quarters inch from the pitch line.

Rock-Faced.—Presenting irregular projecting face, without indications of tool mark.

DESCRIPTIVE WORDS.

Abutment.—A supporting wall carrying the end of a bridge or span and sustaining the pressure of the abutting earth. The abutment of an arch is commonly called a bench wall.

Arris.—The external edge formed by two surfaces, whether plain or curved, meeting each other.

Ashlar.—A squared or cut block of stone with rectangular dimensions.

Backing.—That portion of a masonry wall or structure built in the rear of the face. It must be attached to the face and bonded with it. It is usually of a cheaper grade of work than the face.

Batter.—The slope or inclination of the face or back of a wall from a vertical line.

Bed.—The top and bottom of a stone. (See Course Bed; Natural Bed; Foundation Bed.)

Bed Joint.—A horizontal joint, or one perpendicular to the line of pressure.

Bench Wall.—The abutment from which an arch springs.

Bond.—The mechanical disposition of stone, brick or other building blocks by overlapping to break joints.

Build.—A vertical joint.

Centering.—A temporary support used in arch construction. (Also called centers.)

Clamp.—An instrument for lifting stone so designed that its grip on the surface of the stone is increased as the load is applied. That portion engaging the stone is of wood attached to a steel shoe, which in turn is hinged to the shank of the clamp in such a manner as to adjust itself to the surface of the body lifted.

Coping.—A top course of stone or concrete, generally slightly projecting, to shelter the masonry from the weather, or to distribute the pressure from exterior loading.

Course.—Each separate layer in stone, concrete or brick masonry.

Course Bed.—Stone, brick or other building material in position, upon which other material is to be laid.

Cramps.—Bars of iron having the ends turned at right angles to the body of the bar which enter holes in the upper side of adjacent stones.

Culvert.—A small covered passage for water under a roadway or embankment.

Dimension Stone.—(1) A block of stone cut to specified dimensions.

Dimension Stone.—(2) Large blocks of stone quarried to be cut to specified dimensions.

Dowels.—(a) Straight bars of iron which enter a hole in the upper side of one stone and also a hole in the lower side of the stone next above.

Dowel.—(b) A two-piece steel instrument used in lifting stone. The dowel engages the stone by means of two holes drilled into the stone at an angle of about 45 degrees pointing toward each other. The dowel is not keyed in place.

Draft.—A line on the surface of a stone cut to the breadth of the chisel.

Expansion Joint.—A vertical joint or space to allow for temperature changes.

Extrados.—The upper or convex surface of an arch.

Intrados.—The inner or narrow concave surface of an arch.

Face.—The exposed surface in elevation.

Facing.—In concrete: (1) A rich mortar placed on the exposed surfaces to make a smooth finish.

(2) Shovel facing by working the mortar of concrete to the face.

Final Set.—A stage of the process of setting marked by certain hardness. (See Cement Specifications.)

Flush.—(Adj.) Having the surface even or level with an adjacent surface.

Flush.—(Verb.) (1) To fill. (2) To bring to a level. (3) To force water to the surface of mortar or concrete by compacting or ramming.

Footing.—A projecting bottom course.

Form.—A temporary structure for giving concrete a desired shape.

Foundation.—(1) That portion of a structure usually below the surface of the ground, which distributes the pressure upon its support. (2) Also applied to the natural support itself; rock, clay, etc.

Foundation Bed.—The surface on which a structure rests.

Grout.—A mortar of liquid consistency which can easily be poured.

Header.—A stone which has its greatest length at right angles to the face of the wall, and which bonds the face stones to the backing.

Initial Set.—An early stage of the process of setting, marked by certain hardness. (See Cement Specifications.)

Joint.—The narrow space between adjacent stones, bricks or other building blocks, usually filled with mortar.

Lagging.—Strips used to carry and distribute the weight of an arch to the ribs or centering during its construction.

Lewis.—A four-piece steel instrument used in lifting stone. (The lewis engages the stone by means of a triangular-shaped hole into which it is keyed.)

Lock.—Any special device or method of construction used to secure a bond in the work.

Mortar.—A mixture of fine aggregate, cement or lime and water used to bind together the materials of concrete, stone or brick in masonry or to cover the surface of the same.

Natural Bed.—The surfaces of a stone parallel to its stratification.

Parapet.—A wall or barrier on the edge of an elevated structure for protection or ornament.

Paving.—Regularly placed stone or brick forming a floor.

Pier.—An intermediate support for arches or other spans.

Pitch.—(Verb.) To square a stone.

Pitched.—Having the arris clearly defined by a line beyond which the rock is cut away by the pitching chisel so as to make approximately true edges.

Pointing.—Filling joints or defects in the face of a masonry structure.

Retaining Wall.—A wall for sustaining the pressure of earth or filling deposited behind it.

Voussoirs.—The individual stones forming an arch. They are always of truncated wedge form.

Ring Stones.—The end voussoirs of an arch.

Riprap.—Rough stone of various sizes placed compactly or irregularly to prevent scour by water.

Rubble.—Field stone or rough stone as it comes from the quarry. When it is of a large or massive size it is termed block rubble.

Rubbed.—A fine finish made by rubbing with grit or sandstone.

Set.—(Noun) The change from a plastic to a solid or hard state.

Slope Wall.—A wall to protect the slope of an embankment or cut.

Soffit.—The under side of a projection.

Spall.—(Noun) A chip or small piece of stone broken from a large block.

Spandrel Wall.—The wall at the end of an arch above the springing line and extrados of the arch and below the coping or the string course.

Stretcher.—A stone which has its greatest length parallel to the face of the wall.

Wing Wall.—An extension of an abutment wall to retain the adjacent earth.

* MASONRY.

GENERAL DEFINITION.

The following is a comprehensive definition to cover any kind of masonry, and with the recommendation that in usual practice the word "masonry" be qualified by some proper term to more particularly describe the kind of masonry under consideration:

Masonry, in its widest sense, includes all construction of stone or kindred substitute materials, in which the separate pieces are either placed together, with or without cementing material to join them; or encased in a matrix of firmly cementing material.

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* Adopted, Vol. 3, 1902, pp. 310, 347.

*MASONRY SPECIFICATIONS.

It is recommended that railway companies prepare and use specifications complete in themselves for all kinds of masonry, to be in such form that they may be attached to and form part of specifications and contracts for other railway construction when desirable.

†CONCRETE BRIDGE SEATS.

Concrete, either plain or reinforced, is suitable for bridge seats or pedestal caps.

‡USE OF REINFORCED CONCRETE FOR SMALL OPENINGS.

Good practice permits the use of reinforced concrete for the common forms of construction for small openings.

§SPECIFICATIONS FOR NATURAL AND PORTLAND CEMENT.

(Standard Specifications for Cement adopted by a Joint Committee, embracing representatives from the American Society of Civil Engineers, American Society for Testing Materials, American Institute of Architects, Engineer Department of United States Army, Association of Portland Cement Manufacturers, and American Railway Engineering Association.)

GENERAL OBSERVATIONS.

1. These remarks have been prepared with a view of pointing out the pertinent features of the various requirements and the precautions to be observed in the interpretation of the results of the tests.

2. It is suggested that the acceptance or rejection under these specifications be based on tests made by an experienced person having the proper means for making the tests.

Specific Gravity.

3. Specific gravity is useful in detecting adulteration or underburning. The results of tests of specific gravity are not necessarily conclusive as an indication of the quality of a cement, but when in combination with the results of other tests may afford valuable indications.

Fineness.

4. The sieves should be kept thoroughly dry.

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* Adopted, Vol., 3, 1902, pp. 310, 348.

† Adopted, Vol. 6, 1905, pp. 703, 724, 728, 729.

‡ Adopted, Vol. 6, 1905, pp. 703, 704, 724, 728, 729.

§ Adopted, Vol. 4, 1903, pp. 389-436, 443; Vol. 5, 1904, pp. 605-610; Vol. 6, 1905, pp. 704-718, 723, 724, 726-728; Vol. 11, 1910, pp. 956, 957, 958.

Time of Setting.

5. Great care should be exercised to maintain the test pieces under as uniform conditions as possible. A sudden change or wide range of temperature in the room in which the tests are made, a very dry or humid atmosphere, and other irregularities vitally affect the rate of setting.

Tensile Strength.

6. Each consumer should fix the minimum requirements for tensile strength to suit his own conditions. They should, however, be within the limits stated.

Constancy of Volume.

7. The tests for constancy of volume are divided into two classes, the first normal, the second accelerated. The latter should be regarded as a precautionary test only, and not infallible. So many conditions enter into the making and interpreting of it that it should be used with extreme care.

8. In making the pats the greatest care should be exercised to avoid initial strains due to molding or too rapid drying out during the first twenty-four hours. The pats should be preserved under the most uniform conditions possible, and rapid changes of temperature should be avoided.

9. The failure to meet the requirements of the accelerated tests need not be sufficient cause for rejection. The cement may, however, be held for twenty-eight days, and a retest made at the end of that period. Failure to meet the requirements at this time should be considered sufficient cause for rejection, although in the present state of knowledge it cannot be said that such failure necessarily indicates unsoundness, nor can the cement be considered entirely satisfactory simply because it passes the tests.

STANDARD SPECIFICATIONS FOR CEMENT.

GENERAL CONDITIONS.

1. All cement shall be inspected.

2. Cement may be inspected either at the place of manufacture or on the work.

3. In order to allow ample time for inspecting and testing, the cement shall be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

4. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

5. Every facility shall be provided by the contractor and a period of at least twelve days allowed for the inspection and necessary tests.

6. Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

7. A bag of cement shall contain 94 lbs. of cement net. Each barrel of Portland cement shall contain four bags, and each barrel of Natural cement shall contain three bags of the above net weight.

8. Cement failing to meet the seven-day requirements may be held awaiting the results of the twenty-eight-day tests before rejection.

9. Tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the Society January 21, 1903, and amended January 20, 1904, with all subsequent amendments thereto. (See addendum to these specifications.)

10. The acceptance or rejection shall be based on the following requirements:

NATURAL CEMENT.

Definition.

11. This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Specific Gravity.

12. The specific gravity of the cement, thoroughly dried at 100 degrees Cent., shall not be less than 2.8.

Fineness.

13. It shall leave by weight a residue of not more than 10 per cent. on the No. 100, and 30 per cent. on the No. 200 sieve.

Time of Setting.

14. It shall develop initial set in not less than ten minutes, and hard set in not less than thirty minutes, nor more than three hours.

Tensile Strength.

15. The minimum requirements for tensile strength for briquettes one inch square in cross-section shall be as follows, and shall show no retrogression in strength within the periods specified:*

Age.	Strength.
Neat Cement.	
24 hours in moist air	75 lbs.
7 days (1 day in moist air, 6 days in water)	150 lbs.
28 days (1 day in moist air, 27 days in water)	250 lbs.
One Part Cement, Three Parts Standard Ottawa Sand.	
7 days (1 day in moist air, 6 days in water)	50 lbs.
28 days (1 day in moist air, 27 days in water)	125 lbs.

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* For example, the minimum requirement for the twenty-four hour neat cement tests should show some specified value within the limits of 50 and 100 pounds, and so on for each period stated.

Constancy of Volume.

16. Pats of neat cement about three (3) in. in diameter, one-half (½) in. thick at center, tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air of normal temperature.

(b) Another is kept in water maintained as near 70 degrees Fahrenheit as practicable.

17. These pats are observed at intervals for at least 28 days, and, to satisfactorily pass the tests, should remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

PORTLAND CEMENT.

Definition.

18. This term shall be applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent. has been made subsequent to calcination.

Specific Gravity.

19. The specific gravity of cement shall not be less than 3.10. Should the tests of cement as received fall below this requirement, a second test may be made upon a sample ignited at a low red heat. The loss in weight of the ignited cement shall not exceed 4 per cent.

Fineness.

20. It shall leave by weight a residue of not more than 8 per cent. on the No. 100, and not more than 25 per cent. on the No. 200 sieve.

Time of Setting.

21. It shall develop initial set in not less than thirty minutes, but must develop hard set in not less than one hour, nor more than ten hours.

Tensile Strength.

22. The minimum requirements for tensile strength for briquettes one inch square in cross-section shall be as follows, and shall show no retrogression in strength within the periods specified:*

Age.	Strength.
Neat Cement.	
24 hours in moist air	175 lbs.
7 days (1 day in moist air, 6 days in water)	500 lbs.
28 days (1 day in moist air, 27 days in water)	600 lbs.
One Part Cement, Three Parts Standard Ottawa Sand.	
7 days (1 day in moist air, 6 days in water)	200 lbs.
28 days (1 day in moist air, 27 days in water)	275 lbs.

Constancy of Volume.

23. Pats of neat cement about three (3) in. in diameter, one-half (½) in. thick at the center, and tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

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* For example, the minimum requirement for the twenty-four hour neat cement tests should show some specified value within the limits of 150 and 200 pounds, and so on for each period stated.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.

(b) Another pat is kept in water maintained as near 70 degrees Fahrenheit as practicable, and observed at intervals for at least 28 days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for five hours.

24. These pats, to satisfactorily pass the requirements, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Sulphuric Acid and Magnesia.

25. The cement shall not contain more than 1.75 per cent. of anhydrous sulphuric acid (SO_3), nor more than 4 per cent. of magnesia (MgO).

ADDENDUM.

REPORT OF THE SPECIAL COMMITTEE ON UNIFORM TESTS OF CEMENT.

Authorized Reprint from the Copyrighted Proceedings of the American Society of Civil Engineers, pp. 105-118, February, 1911.

SAMPLING.

Selection of Sample.

1. The selection of the sample for testing is a detail that must be left to the discretion of the engineer; the number and the quantity to be taken from each package will depend largely on the importance of the work, the number of tests to be made and the facilities for making them.

2. The sample shall be a fair average of the contents of the package; it is recommended that, where conditions permit, one barrel in every ten be sampled.

3. Samples should be passed through a sieve having twenty meshes per linear inch, in order to break up lumps and remove foreign material; this is also a very effective method for mixing them together in order to obtain an average. For determining the characteristics of a shipment of cement, the individual samples may be mixed and the average tested; where time will permit, however, it is recommended that they be tested separately.

Method of Sampling.

4. Cement in barrels should be sampled through a hole made in the center of one of the staves, midway between the heads, or in the head, by means of an auger or a sampling iron similar to that used by sugar inspectors. If in bags, it should be taken from surface to center.

CHEMICAL ANALYSIS.

Significance. 5. Chemical analysis may render valuable service in the detection of adulteration of cement with considerable amounts of inert material, such as slag or ground limestone. It is of use, also, in determining whether certain constituents, believed to be harmful when in excess of a certain percentage, as magnesia and sulphuric anhydride, are present in inadmissible proportions.

6. The determination of the principal constituents of cement—silica, alumina, iron oxide and lime—is not conclusive as an indication of quality. Faulty character of cement results more frequently from imperfect preparation of the raw material or defective burning than from incorrect proportions of the constituents. Cement made from very finely ground material and thoroughly burned may contain much more lime than the amount usually present, and still be perfectly sound. On the other hand, cements low in lime may, on account of careless preparation of the raw material, be of dangerous character. Further, the ash of the fuel used in burning may so greatly modify the composition of the product as largely to destroy the significance of the results of analysis.

Method. 7. As a method to be followed for the analysis of cement, that proposed by the Committee on Uniformity in the Analysis of Materials for the Portland Cement Industry, of the New York Section of the Society for Chemical Industry, and published in Engineering News, Vol. 50, p. 60, 1903, and in Engineering Record, Vol. 48, p. 49, 1903, is recommended.

SPECIFIC GRAVITY.

Significance. 8. The specific gravity of cement is lowered by adulteration and hydration, but the adulteration must be in considerable quantity to affect the results appreciably.

9. Inasmuch as the differences in specific gravity are usually very small, great care must be exercised in making the determination.

Apparatus and Method. 10. The determination of specific gravity is most conveniently made with Le Chatelier's apparatus. This consists of a flask (*D*), Fig. 1, of 120 cu. cm. (7.32 cu. in.) capacity, the neck of which is about 20 cm. (7.87 in.) long; in the middle of this neck is a bulb (*C*), above and below which are two marks (*F*) and (*E*); the volume between these marks is 20 cu. cm. (1.22 cu. in.) The neck has a diameter of about 9 mm. (0.35 in.), and is graduated into tenths of cubic centimeters above the mark (*F*).

11. Benzine (62 degrees Baumé naphtha), or kerosene free from water, should be used in making the determination.

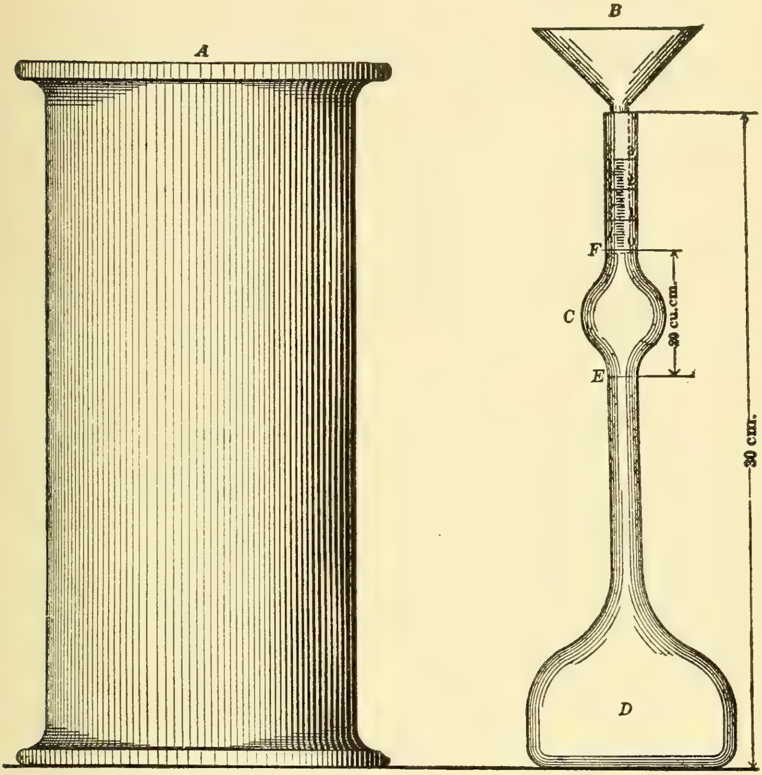

Fig. 1. Le Chatelier's Specific Gravity Apparatus.

12. The specific gravity is determined as follows:

The flask is filled with either of these liquids to the lower mark (*E*), and 64 g. (2.25 oz.) of powder, cooled to the temperature of the liquid, is gradually introduced through the funnel (*B*) [the stem of which extends into the flask to the top of the bulb (*C*), until all the powder is introduced, and the level of the liquid rises to some division of the graduated neck. This reading plus 20 cu. cm. is the volume displaced by 64 g. of the powder.

13. The specific gravity is then obtained from the formula:

$$\text{Specific Gravity} = \frac{\text{Weight of Cement, in grammes.}}{\text{Displaced Volume, in cubic centimeters.}}$$

14. The flask, during the operation, is kept immersed in water in a jar (A), in order to avoid variations in the temperature of the liquid. The results should agree within 0.01. The determination of specific gravity should be made on the cement as received; and, should it fall below 3.10, a second determination should be made on the sample ignited at a low red heat.

15. A convenient method for cleaning the apparatus is as follows: The flask is inverted over a large vessel, preferably a glass jar, and shaken vertically until the liquid starts to flow freely; it is then held still in a vertical position until empty; the remaining traces of cement can be removed in a similar manner by pouring into the flask a small quantity of clean liquid benzine or kerosene and repeating the operation.

FINENESS.

Significance. 16. It is generally accepted that the coarser particles in cement are practically inert, and it is only the extremely fine powder that possesses adhesive or cementing qualities. The more finely cement is pulverized, all other conditions being the same, the more sand it will carry and produce a mortar of a given strength.

17. The degree of final pulverization which the cement receives at the place of manufacture is ascertained by measuring the residue retained on certain sieves. Those known as the No. 100 and No. 200 sieves are recommended for this purpose.

Apparatus. 18. The sieves should be circular, about 20 cm. (7.87 in.) in diameter, 6 cm. (2.36 in.) high, and provided with a pan 5 cm. (1.97 in.) deep, and a cover.

19. The wire cloth should be of brass wire having the following diameter:

No. 100, 0.0045 in.; No. 200, 0.0024 in.

20. This cloth should be mounted on the frames without distortion; the mesh should be regular in spacing and be within the following limits:

No. 100, 96 to 100 meshes to the linear inch.
No. 200, 188 to 200 meshes to the linear inch.

21. Fifty grammes (1.76 oz.) or 100 g. (3.52 oz.) should be used for the test, and dried at a temperature of 100 degrees Cent. (212 degrees Fahrenheit) prior to sieving.

Method. 22. The thoroughly dried and coarsely screened sample is weighed and placed on the No. 200 sieve, which, with pan and cover attached, is held in one hand in a slightly inclined position, and moved forward and backward, at the same time striking the side gently with the palm of the other hand, at the rate of about 200 strokes per minute. The operation is continued until not more than one-tenth of 1 per cent. passes through after one minute of continuous sieving. The residue is weighed, then placed on the No. 100 sieve and the operation repeated. The work may be expedited by placing in the sieve a small quantity of large steel shot. The results should be reported to the nearest tenth of 1 per cent.

NORMAL CONSISTENCY.

Significance.

23. The use of a proper percentage of water in making the pastes* from which pats, tests of setting and briquettes are made, is exceedingly important, and affects vitally the results obtained.

24. The determination consists in measuring the amount of water required to reduce the cement to a given state of plasticity, or to what is usually designated the normal consistency.

25. The Committee recommends the following method for determining normal consistency:

Method.

26. This can best be determined by means of *Vicat Needle Apparatus,* which consists of a frame (K), Fig. 2, bearing a movable rod

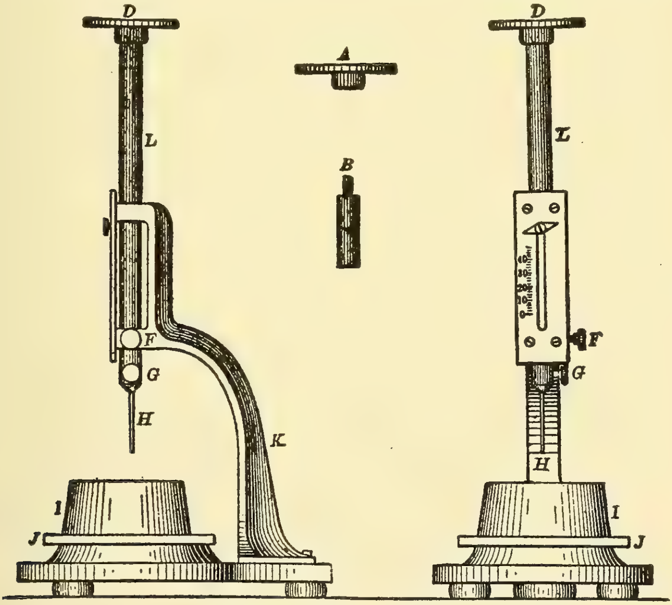

Fig. 2. Vicat Needle.

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* The term "paste" is used in this report to designate a mixture of cement and water, and the word "mortar" a mixture of cement, sand and water.

(*L*), with the cap (*A*) at one end, and at the other the cylinder (*B*), 1 cm. (0.39 in.) in diameter, the cap, rod and cylinder weighing 300 g. (10.58 oz.). The rod, which can be held in any desired position by a screw (*F*), carries an indicator, which moves over a scale (graduated to centimeters) attached to the frame (*K*). The paste is held by a conical hard-rubber ring (*I*), 7 cm. (2.76 in.) in diameter at the base, 4 cm. (1.57 in.) high, resting on a glass plate (*J*), about 10 cm. (3.94 in.) square.

27. In making the determination, the same quantity of cement as will be subsequently used for each batch in making the briquettes [but not less than 500 g. (17.16 oz.)] is kneaded into a paste, as described in paragraph 52, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained 6 in. apart; the ball is then pressed into the rubber ring, through the larger opening, smoothed off and placed (on its large end) on a glass plate and the smaller end smoothed off with a trowel; the paste, confined in the ring, resting on the plate, is placed under the rod bearing the cylinder, which is brought in contact with the surface and quickly released.

28. The paste is of normal consistency when the cylinder in one minute from the time it is released penetrates to a point in the mass 10 mm. (0.39 in.) below the top of the ring. Great care must be taken to fill the ring exactly to the top. The apparatus must be free from all vibrations during the test.

29. The trial pastes are made with varying percentages of water until the correct consistency is obtained.

30. The Committee has recommended, as normal, a paste, the consistency of which is rather wet, because it believes that variations in the amount of compression to which the briquette is subjected in molding are likely to be less with such a paste.

31. Having determined in this manner the proper percentage of water required to produce a paste of normal consistency, the proper percentage required for the mortars is obtained from the table below:

PERCENTAGE OF WATER FOR STANDARD SAND MORTARS.

Neat.	One Cement Three Standard Ottawa Sand.	Neat.	One Cement Three Standard Ottawa Sand.	Neat.	One Cement Three Standard Ottawa Sand.
15	8.0	23	9.3	31	10.7
16	8.2	24	9.5	32	10.8
17	8.3	25	9.7	33	11.0
18	8.5	26	9.8	34	11.2
19	8.7	27	10.0	35	11.5
20	8.8	28	10.2	36	11.5
21	9.0	29	10.3	37	11.7
22	9.2	30	10.5	38	11.8

TIME OF SETTING.

Significance.

32. The object of this test is to determine the time which elapses from the moment water is added until the paste ceases to be fluid and plastic (called the "initial set"), and also the time required for it to acquire a certain degree of hardness (called the "final" or "hard set"). The former of these is the more important, since, with the commencement of setting, the process of crystallization or hardening is said to begin. As a disturbance of this process may produce a loss of strength, it is desirable to complete the operation of mixing and molding or incorporating the mortar into the work before the cement begins to set.

33. It is usual to measure arbitrarily the beginning and end of the setting by the penetration of weighted wires of given diameters.

Method.

34. For this purpose the Vicat Needle, which has already been described in paragraph 26, should be used.

35. In making the test, a paste of normal consistency is molded and placed under the rod (*L*), Fig. 2, as described in paragraph 27; this rod, bearing the cap (*D*) at one end and the needle (*H*), 1 mm. (0.039 in.) in diameter, at the other, weighing 300 g. (10.58 oz.). The needle is then carefully brought in contact with the surface of the paste and quickly released.

36. The setting is said to have commenced when the needle ceases to pass a point 5 mm. (0.20 in.) above the upper surface of the glass plate, and is said to have terminated the moment the needle does not sink visibly into the mass.

37. The test pieces should be stored in moist air during the test; this is accomplished by placing them on a rack over water contained in a pan and covered with a damp cloth, the cloth to be kept away from them by means of a wire screen; or they may be stored in a moist box or closet.

38. Care should be taken to keep the needle clean, as the collection of cement on the sides of the needle retards the penetration, while cement on the point reduces the area and tends to increase the penetration.

39. The determination of the time of setting is only approximate, being materially affected by the temperature of the mixing water, the temperature and humidity of the air during the test, the percentage of water used, and the amount of kneading the paste receives.

STANDARD SAND.

Standard Sand.

40. For the present, the use of the natural sand from Ottawa, Ill., screened to pass a sieve having 20 meshes per linear inch and retained on a sieve having 30 meshes per linear inch is recommended; the wires to have diameters of 0.0165 and 0.0112 in., respectively, *i. e.,* half the width of the opening in each case. Sand having passed the No. 20 sieve shall be considered standard when not more than 1 per cent. passes a No. 30 sieve after one minute's continuous sifting of a 500-g. sample.*

FORM OF TEST PIECES.

41. For tension tests the Committee recommends the form of test piece shown in Fig. 3.

42. For compression tests a 2-inch cube is recommended.

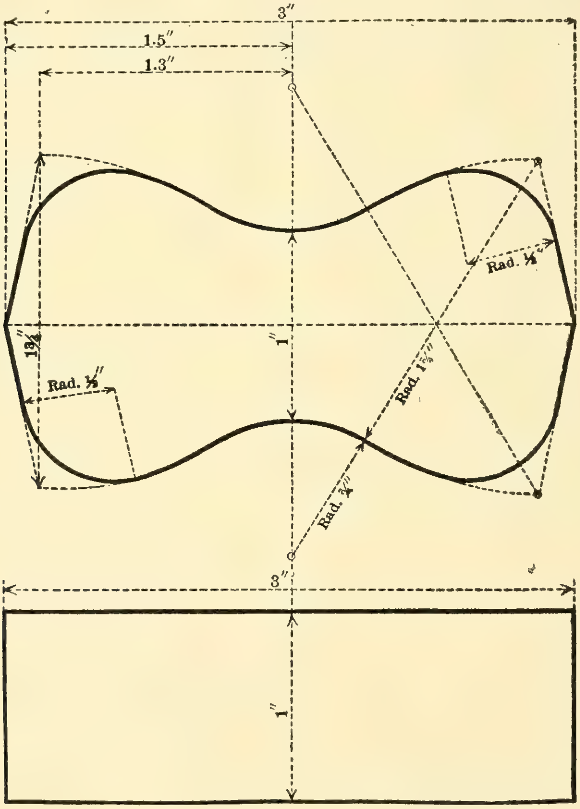

FIG. 3.—DETAILS FOR BRIQUETTE.

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* This sand may be obtained from the Ottawa Silica Company at a cost of two cents per pound f. o. b. cars, Ottawa, Ill.

MOLDS.

Molds.

43. The molds should be made of brass, bronze or some equally non-corrosive material, having sufficient metal in the sides to prevent spreading during molding.

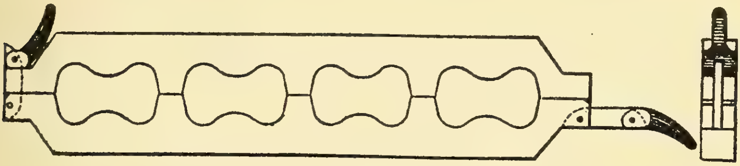

FIG. 4.—DETAILS FOR GANG MOLD.

44. Gang molds, which permit molding a number of briquettes at one time, are preferred by many to single molds; since the greater quantity of mortar that can be mixed tends to produce a greater uniformity in the results. The type shown in Figs. 4 and 5 is recommended.

45. The molds should be wiped with an oily cloth before using.

MIXING.

Mixing.

46. All proportions should be stated by weight; the quantity of water to be used should be stated as a percentage of the dry material.

47. The metric system is recommended because of the convenient relation of the gramme and the cubic centimeter.

48. The temperature of the room and the mixing water should be as near 21 degrees Cent. (70 degrees Fahrenheit) as it is practical to maintain it.

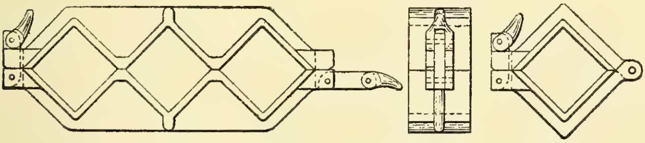

FIG. 5.—MOLD FOR COMPRESSION TEST PIECES.

49. The sand and cement should be thoroughly mixed dry. The mixing should be done on some non-absorbing surface, preferably plate glass. If the mixing must be done on an absorbing surface it should be thoroughly dampened prior to use.

50. The quantity of material to be mixed at one time depends on the number of test pieces to be made; about 1000 g. (35.28 oz.) makes a convenient quantity to mix, especially by hand methods.

51. The Committee, after investigation of the various mechanical mixing machines, has decided not to recommend any machine that has thus far been devised, for the following reasons:

(1) The tendency of most cement is to "ball up" in the machine, thereby preventing the working of it into a homogeneous paste; (2) there are no means of ascertaining when the mixing is complete without stopping the machine, and (3) the difficulty of keeping the machine clean.

Method.

52. The material is weighed and placed on the mixing table, and a crater formed in the center, into which the proper percentage of clean water is poured; the material on the outer edge is turned into the crater by the aid of a trowel. As soon as the water has been absorbed, which should not require more than one minute, the operation is completed by vigorously kneading with the hands for an additional 1 minute, the process being similar to that used in kneading dough. A sandglass affords a convenient guide for the time of kneading. During the operation of mixing the hands should be protected by gloves, preferably of rubber.

MOLDING.

53. Having worked the paste or mortar to the proper consistency, it is at once placed in the molds by hand.

54. The Committee has been unable to secure satisfactory results with the present molding machines; the operation of machine molding is very slow, and the present types permit of molding but one briquette at a time, and are not practicable with the pastes or mortars herein recommended.

Method.

55. The molds should be filled immediately after the mixing is completed, the material pressed in firmly with the fingers and smoothed off with a trowel without mechanical ramming; the material should be heaped up on the upper surface of the mold, and, in smoothing off, the trowel should be drawn over the mold in such a manner as to exert a moderate pressure on the excess material. The mold should be turned over and the operation repeated.

56. A check upon the uniformity of the mixing and molding is afforded by weighing the briquettes just prior to immersion, or upon removal from the moist closet. Briquettes which vary in weight more than 3 per cent. from the average should not be tested.

STORAGE OF THE TEST PIECES.

57. During the first 24 hours after molding, the test pieces should be kept in moist air to prevent them from drying out.

Method.

58. A moist closet or chamber is so easily devised that the use of the damp cloth should be abandoned if possible. Covering the test pieces with a damp cloth is objectionable, as commonly used, because the cloth may dry out unequally, and in consequence the test pieces are not all maintained under the same condition. Where a moist closet is not available, a cloth may be used and kept uniformly wet by immersing the ends in water. It should be kept from direct contact with the test pieces by means of a wire screen or some similar arrangement.

59. A moist closet consists of a soapstone or slate box, or a metal-lined wooden box—the metal lining being covered with felt and this felt kept wet. The bottom of the box is so constructed as to hold water, and the sides are provided with cleats for holding glass shelves on which to place the briquettes. Care should be taken to keep the air in the closet uniformly moist.

60. After 24 hours in moist air, the test pieces for longer periods of time should be immersed in water maintained as near 21 degrees Cent. (70 degrees Fahrenheit) as practicable; they may be stored in tanks or pans, which should be of non-corrodible material.

TENSILE STRENGTH.

Tensile Strength.

61. The tests may be made on any machine. A solid metal clip, as shown in Fig. 6, is recommended. This clip is to be used without cushioning at the points of contact with the test specimen. The bearing at each point of contact should be ¼-in. wide, and the distance between the center of contact on the same clip should be 1¼ in.

62. Test pieces should be broken as soon as they are removed from the water. Care should be observed in centering the briquettes in the testing machine, as cross-strains, produced by improper centering, tend to lower the breaking strength. The load should not be applied too suddenly, as it may produce vibration, the shock from which often breaks the briquette before the ultimate strength is reached. Care must be taken that the clips and the sides of the briquette be clean and free from grains of sand or dirt which would prevent a good bearing. The load should be applied at the rate of 600 lbs. per minute. The average of the briquettes of each sample tested should be taken as the test, excluding any results which are manifestly faulty.

COMPRESSIVE STRENGTH.

63. The tests may be made in any machine provided with a means for so applying the load that the line of pressure is along the axis of the test piece. A ball-bearing block for this purpose is shown in Fig. 7.

64. Some appliance to facilitate placing the center of the ball-bearing exactly in the line of the axis of the test piece should be provided.

The test piece should be placed in the testing machine with a piece of heavy blotting paper on each of the crushing faces, which should be those that were in contact with the mold.

The test piece should be broken as soon as removed from the water.

CONSTANCY OF VOLUME.

Significance. 65. The object is to develop those qualities which tend to destroy the strength and durability of a cement. As it is highly essential to determine such qualities at once tests of this character are for the most part made in a very short time, and are known, therefore, as accelerated tests. Failure is revealed by cracking, checking, swelling or distintegra-

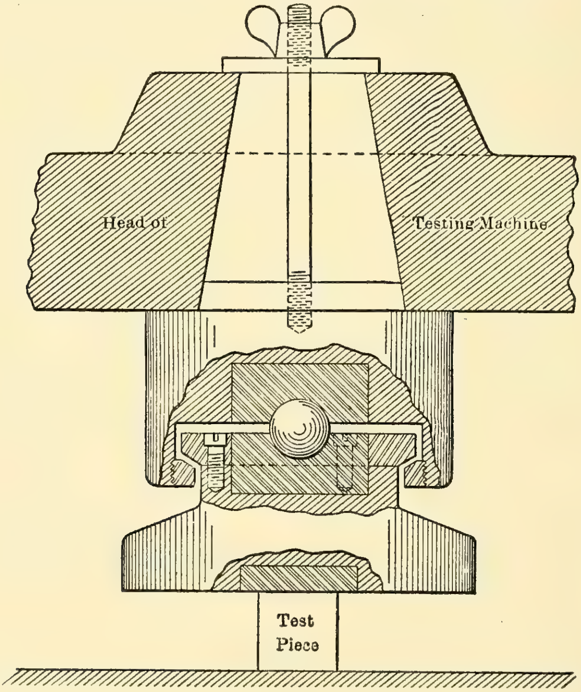

Fig. 7.

tion, or all of these phenomena. A cement which remains perfectly sound is said to be of constant volume.

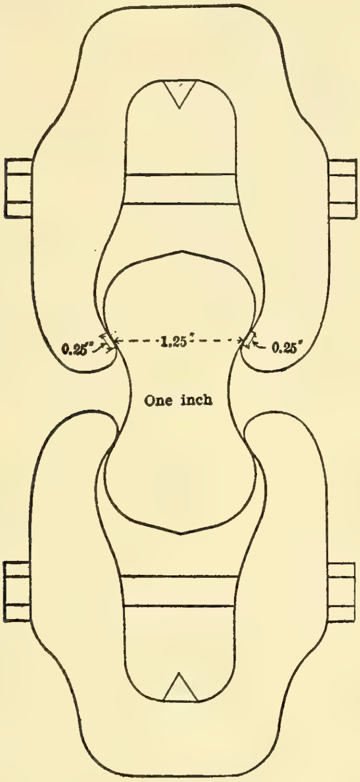

FIG. 6.—FORM OF CLIP.

Method.

66. Tests for constancy of volume are divided into two classes: (1) Normal tests, or those made in either air or water maintained at about 21 degrees Cent. (70 degrees Fahrenheit), and (2) accelerated tests, or those made in air, steam or water at a temperature of 45 degrees Cent. (113 degrees Fahrenheit) and upward. The test pieces should be allowed to remain 24 hours in moist air before immersion in water or steam, or preservation in air.

67. For these tests, pats about 7½ cm. (2.95 in.) in diameter, 1¼ cm. (0.49 in.) thick at the center, and tapering to a thin edge, should

be made, upon a clean glass plate [about 10 cm. (3.94 in.) square], from cement paste of normal consistency.

Normal Test.

68. A pat is immersed in water maintained as near 21 degrees Cent. (70 degrees Fahrenheit) as possible for 28 days, and observed at intervals. A similar pat, after 24 hours in moist air, is maintained in air at ordinary temperature and observed at intervals.

Accelerated Test.

69. A pat is placed in an atmosphere of steam upon a wire screen one inch above boiling water for five (5) hours.

The apparatus should be so constructed as to permit the free escape of steam and maintain atmospheric pressure.

Since the type of apparatus used has a great influence on the uniformity of the results, that shown in Fig. 8 is recommended.

70. To pass these tests satisfactorily, the pats should remain firm and hard, and show no signs of cracking, distortion or disintegration.

71. Should the pat leave the plate, distortion may be detected best with a straight-edge applied to the surface which was in contact with the plate.

72. In the present state of our knowledge it cannot be said that cement should necessarily be condemned simply for failure to pass the accelerated tests; nor can a cement be considered entirely satisfactory simply because it has passed these tests.

METHOD SUGGESTED FOR THE ANALYSIS OF LIMESTONE, RAW MIXTURES AND PORTLAND CEMENTS BY THE COMMITTEE ON UNIFORMITY IN TECHNICAL ANALYSIS OF THE NEW YORK SECTION SOCIETY FOR CHEMICAL INDUSTRY.

Solution.

One-half gramme of the finely powdered substance is to be weighed out and, if a limestone or unburned mixture, strongly ignited in a covered platinum crucible over a strong blast for fifteen minutes, or longer if the blast is not powerful enough to effect complete conversion to a cement in this time. It is then transferred to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, moistened with enough water to prevent lumping, and 5 to 10 c.c. of strong HCl added and digested with the aid of gentle heat and agitation until solution is complete. Solution may be aided by light pressure with the flattened end of a glass rod.* The solution is then evaporated to dryness, as far as this may be possible on the bath.

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* If anything remains undecomposed it should be separated, fused with a little Na_2CO_2, dissolved and added to the original solution. Of course a small amount of separated non-gelatinous silica is not to be mistaken for undecomposed matter.

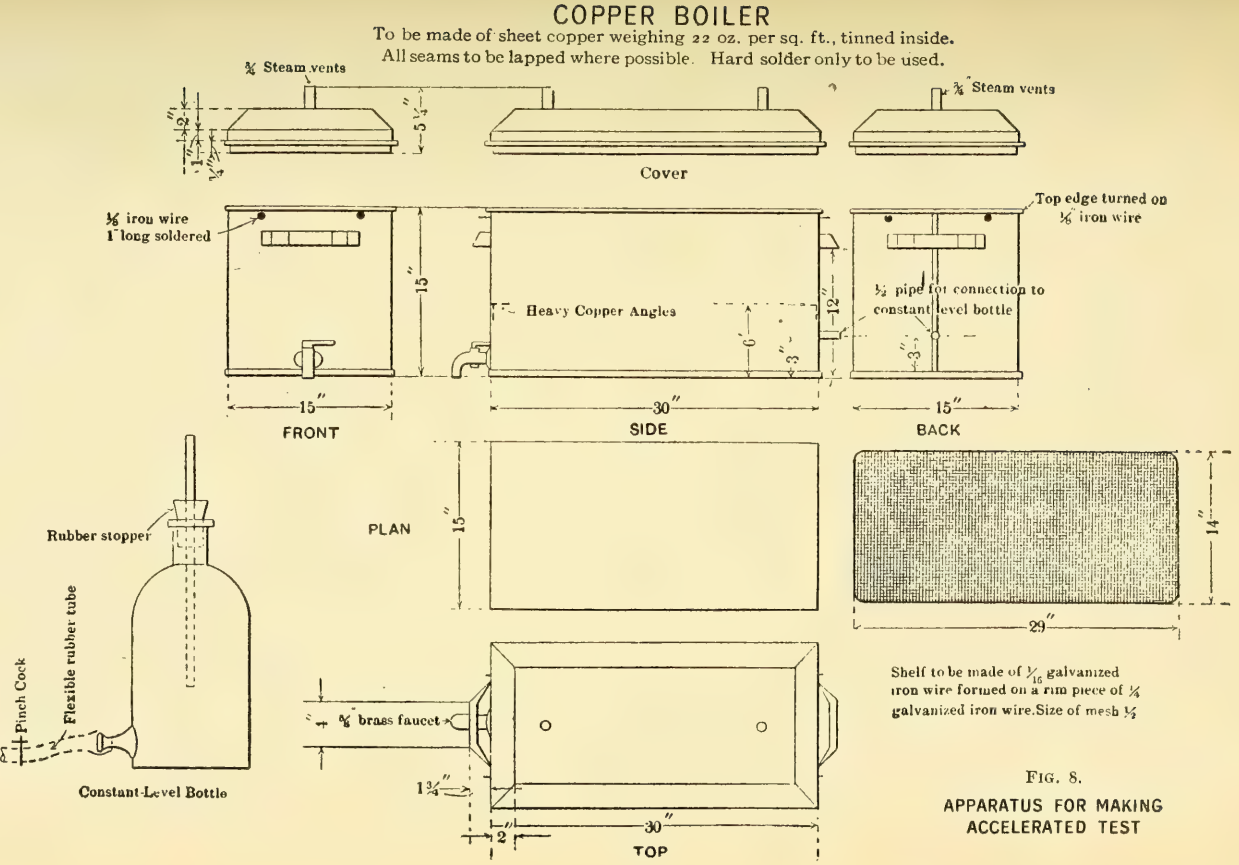
COPPER BOILER
To be made of sheet copper weighing 22 oz. per sq. ft., tinned inside.
All seams to be lapped where possible. Hard solder only to be used.
⅜ Steam vents
⅜" Steam vents
2"
1"
¼"
5¼"
Cover
⅜ iron wire
1" long soldered
Top edge turned on
⅛" iron wire
15"
Heavy Copper Angles
6"
3"
12"
½ pipe for connection to
constant level bottle
3"
15"
FRONT
30"
SIDE
15"
BACK
PLAN
15"
14"
29"
Rubber stopper
Pinch Cock
Flexible rubber tube
2"
Constant-Level Bottle
⅝" brass faucet
1¾"
2"
30"
TOP
Shelf to be made of $\frac{1}{16}$ galvanized
iron wire formed on a rim piece of ¼
galvanized iron wire. Size of mesh ½

Fig. 8.

APPARATUS FOR MAKING ACCELERATED TEST

Fig. 8.

Silica (SiO_2).

The residue without further heating is treated at first with 5 to 10 c.c. of strong HCl which is then diluted to half strength or less, or upon the residue may be poured at once a larger volume of acid of half strength. The dish is then covered and digestion allowed to go on for 10 minutes on the bath, after which the solution is filtered and the separated silica washed thoroughly with water. The filtrate is again evaporated to dryness, the residue without further heating, taken up with acid and water and the small amount of silica it contains separated on another filter paper. The papers containing the residue are transferred wet to a weighed platinum crucible, dried, ignited, first over a Bunsen burner until the carbon of the filter is completely consumed, and finally over the blast for 15 minutes and checked by a further blasting for 10 minutes or to constant weight. The silica, if great accuracy is desired, is treated in the crucible with about 10 c.c. of HFl and four drops of H_2SO_4, and evaporated over a low flame to complete dryness. The small residue is finally blasted, for a minute or two, cooled and weighed. The difference between this weight and the weight previously obtained gives the amount of silica.*

Alumina and Iron (Al_2O_3 and Fe_2O_3).

The filtrate, about 250 c.c., from the second evaporation for SiO_2, is made alkaline with NH_4OH after adding HCl, if need be, to insure a total of 10 to 15 c.c. strong acid, and boiled to expell excess of NH_3, or until there is but a faint odor of it, and the precipitate iron and aluminum hydrates, after settling, are washed once by decantation and slightly on the filter. Setting aside the filtrate, the precipitate is dissolved in hot dilute HCl, the solution passing into the beaker in which the precipitation was made. The aluminum and iron are then reprecipitated by NH_4OH, boiled and the second precipitate collected and washed on the same filter used in the first instance. The filter paper, with the precipitate, is then placed in a weighed platinum crucible, the paper burned off and the precipitate ignited and finally blasted 5 minutes, with care to prevent reduction, cooled and weighed as $Al_2O_3+Fe_2O_3$.†

Iron (Fe_2O_3).

The combined iron and aluminum oxides are fused in a platinum crucible at a very low temperature with about 3 or 4 grammes of $KHSO_4$, or, better, $NaHSO_4$, the melt taken up with so much dilute H_2SO_4 that there shall be no less than 5 grammes absolute acid and enough water to effect solution on heating. The solution is then evaporated and eventually heated till acid fumes come off copiously. After cooling and redissolving in water the small amount of silica is filtered out, weighed and corrected by HFl and H_2SO_4.* The filtrate is reduced by zinc, or preferably by hydrogen sulphide, boiling out the excess of the latter afterwards while passing CO_2, through the flask, and titrated with permanganate.† The strength of the permanganate solution should not be greater than .0040 g. Fe_2O_3 per c.c.

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* For ordinary control in the plant laboratory this correction may, perhaps, be neglected; the double evaporation never.

† This precipitate contains TiO_2, P_2O_5, Mn_3O_4.

Lime (CaO).

To the combined filtrate from the $Al_2O_3+Fe_2O_3$ precipitate a few drops of NH_4OH are added, and the solution brought to boiling. To the boiling solution 20 c.c. of a saturated solution of ammonium oxalate are added, and the boiling continued until the precipitated CaC_2O_4 assumes a well-defined granular form. It is then allowed to stand for 20 minutes, or until the precipitate has settled, and then filtered and washed. The precipitate and filter are placed wet in a platinum crucible, and the paper burned off over a small flame of a Bunsen burner. It is then ignited, redissolved in HCl, and the solution made up to 100 c.c. with water. Ammonia is added in slight excess, and the liquid is boiled. If a small amount of Al_2O_3 separates this is filtered out, weighed, and the amount added to that found in the first determination, when greater accuracy is desired. The lime is then reprecipitated by ammonium oxalate, allowed to stand until settled, filtered and washed,‡ weighed as oxide by ignition and blasting in a covered crucible to constant weight, or determined with dilute standard permanganate.§

Magnesia (MgO).

The combined filtrates from the calcium precipitates are acidified with HCl and concentrated on the steam bath to about 150 c.c., 10 c.c. of saturated solution of $Na(NH_4)HPO_4$ are added, and the solution boiled for several minutes. It is then removed from the flame and cooled by placing the beaker in ice water. After cooling, NH_4OH is added drop by drop with constant stirring until the crystalline ammonium-magnesium ortho-phosphate begins to form, and then in moderate excess, the stirring being continued for several minutes. It is then set aside for several hours in a cool atmosphere and filtered. The precipitate is redissolved in hot dilute HCl, the solution made up to about 100 c.c., 1 c.c. of a saturated solution of $Na(NH_4)HPO_4$ added, and ammonia drop by drop, with constant stirring until the precipitate is again formed as described and the ammonia is in moderate excess. It is then allowed to stand for about 2 hours, when it is filtered on a paper or a Gooch crucible, ignited, cooled and weighed as $Mg_2P_2O_7$.

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* This correction of $Al_2O_3Fe_2O_3$ for silica should not be made when the HFl correction of the main silica has been omitted, unless that silica was obtained by only one evaporation and filtration. After two evaporations and filtrations 1 to 2 mg. of SiO are still to be found with the $Al_2O_3Fe_2O_3$.

† In this way only is the influence of titanium to be avoided and a correct result obtained for iron.

‡ The volume of wash-water should not be too large; *vide* Hillebrand.

§ The accuracy of this method admits of criticism, but its convenience and rapidity demand its insertion.

Alkalies (K_2O and Na_2O).

For the determination of the alkalies, the well-known method of Prof. J. Lawrence Smith is to be followed, either with or without the addition of $CaCO_3$ with NH_4Cl.

Anhydrous Sulphuric Acid (SO_3).

One gramme of the substance is dissolved in 15 c.c. of HCl, filtered and residue washed thoroughly.*

The solution is made up to 250 c.c. in a beaker and boiled. To the boiling solution 10 c.c. of a saturated solution of $BaCl_2$ is added slowly drop by drop from a pipette and the boiling continued until the precipitate is well formed, or digestion on the steam bath may be substituted for the boiling. It is then set aside over night, or for a few hours, filtered, ignited and weighed as $BaSO_4$.

Total Sulphur.

One gramme of the material is weighed out in a large platinum crucible and fused with Na_2CO_3 and a little KNO_3 being careful to avoid contamination from sulphur in the gases from source of heat. This may be done by fitting the crucible in a hole in an asbestos board. The melt is treated in the crucible with boiling water and the liquid poured into a tall narrow beaker and more hot water added until the mass is disintegrated. The solution is then filtered. The filtrate contained in a No. 4 beaker is to be acidulated with HCl and made up to 250 c.c. with distilled water, boiled, the sulphur precipitated as $BaSO_4$ and allowed to stand over night or for a few hours.

Loss on Ignition.

Half a gramme of cement is to be weighed out in a platinum crucible, placed in a hole in an asbestos board so that about three-fifths of the crucible projects below, and blasted 15 minutes, preferably with an inclined flame. The loss by weight, which is checked by a second blasting of 5 minutes, is the loss on ignition.

May, 1903: Recent investigations have shown that large errors in results are often due to the use of impure distilled water and reagents. The analyst should, therefore, test his distilled water by evaporation and his reagents by appropriate tests before proceeding with his work.

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* Evaporation to dryness is unnecessary, unless gelatinous silica should have separated and should never be performed on a bath heated by gas; *vide* Hillebrand.

*SPECIFICATIONS FOR STONE MASONRY.

GENERAL.

1. The classification of masonry and the requirements for cement and concrete shall be those adopted by the American Railway Engineering Association. **Standard Specifications.**

2. Where the term "Engineer" is used in these specifications, it refers to the engineer actually in charge of the work. **Engineer Defined.**

GENERAL REQUIREMENTS.

3. Stone shall be of the kinds designated and shall be hard and durable, of approved quality and shape, free from seams, or other imperfections. Unseasoned stone shall not be used where liable to injury by frost. **Stone.**

4. Dressing shall be the best of the kind specified. **Dressing.**

5. Beds and joints or builds shall be square with each other, and dressed true and out of wind. Hollow beds shall not be permitted.

6. Stone shall be dressed for laying on the natural bed. In all cases the bed shall not be less than the rise.

7. Marginal drafts shall be neat and accurate.

8. Pitching shall be done to true lines and exact batter.

9. Mortar shall be mixed in a suitable box, or in a machine mixer, preferably of the batch type, and shall be kept free from foreign matter. The size of the batch and the proportions and the consistency shall be as directed by the engineer. When mixed by hand the sand and cement shall be mixed dry, the requisite amount of water then added and the mixing continued until the cement is uniformly distributed and the mass is uniform in color and homogeneous. **Mortar.**

10. The arrangement of courses and bond shall be as indicated on the drawings, or as directed by the engineer. Stone shall be laid to exact lines and levels, to give the required bond and thickness of mortar in beds and joints. **Laying.**

11. Stone shall be cleansed and dampened before laying.

12. Stone shall be well bonded, laid on its natural bed and solidly settled into place in a full bed of mortar.

13. Stone shall not be dropped or slid over the wall, but shall be placed without jarring stone already laid.

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* Adopted, Vol. 7, 1906, pp. 581-587, 602-604, 606-622; Vol. 8, p. 634; Vol. 9, 1908, pp. 650-655, 659; Vol. 12, 1911.

14. Heavy hammering shall not be allowed on the wall after a course is laid.

15. Stone becoming loose after the mortar is set shall be relaid with fresh mortar.

16. Stone shall not be laid in freezing weather, unless directed by the engineer. If laid, it shall be freed from ice, snow or frost by warming; the sand and water used in the mortar shall be heated.

17. With precaution, a brine may be substituted for the heating of the mortar. The brine shall consist of one pound of salt to eighteen gallons of water, when the temperature is 32 degrees Fahrenheit; for every degree of temperature below 32 degrees Fahrenheit, one ounce of salt shall be added.

Pointing.

18. Before the mortar has set in beds and joints, it shall be removed to a depth of not less than one (1) in. Pointing shall not be done until the wall is complete and mortar set; nor when frost is in the stone.

19. Mortar for pointing shall consist of equal parts of sand, sieved to meet the requirements, and Portland cement. In pointing, the joints shall be wet, and filled with mortar, pounded in with a "set-in" or calking tool and finished with a beading tool the width of a joint, used with a straight-edge.

BRIDGE AND RETAINING WALL MASONRY—ASHLAR STONE.

Bridge and Retaining Wall Masonry. Ashlar Stone.

20. The stone shall be large and well proportioned. Courses shall not be less than fourteen (14) in. or more than thirty (30) in. thick, thickness of courses to diminish regularly from bottom to top.

Dressing.

21. Beds and joints or builds of face stone shall be fine-pointed, so that the mortar layer should not be more than one-half (½) in. thick when the stone is laid.

22. Joints in face stone shall be full to the square for a depth equal to at least one-half the height of the course, but in no case less than twelve (12) in.

Face or Surface.

23. Exposed surfaces of the face stone shall be rock-faced, and edges pitched to the true lines and exact batter; the face shall not project more than three (3) in. beyond the pitch line.

24. Chisel drafts one and one-half (1½) in. wide shall be cut at exterior corners.

25. Holes for stone hooks shall not be permitted to show in exposed surfaces. Stone shall be handled with clamps, keys, lewis or dowels.

Stretchers.

26. Stretchers shall not be less than four (4) ft. long and have at least one and a quarter times as much bed as thickness of course.

Headers. 27. Headers shall not be less than four (4) ft. long, shall occupy one-fifth of face of wall, shall not be less than eighteen (18) in. wide in face, and, where the course is more than eighteen (18) in. high, width of face shall not be less than height of course.

28. Headers shall hold in heart of wall the same size shown in face, so arranged that a header in a superior course shall not be laid over a joint, and a joint shall not occur over a header; the same disposition shall occur in back of wall.

29. Headers in face and back of wall shall interlock when thickness of wall will admit.

30. Where the wall is three (3) ft. thick or less, the face stone shall pass entirely through. Backing shall not be permitted.

Backing. *31-a. Backing shall be large, well-shaped stone, roughly bedded and jointed; bed joints shall not exceed one (1) in. At least one-half of the backing stone shall be of same size and character as the face stone and with parallel ends. The vertical joints in back of wall shall not exceed two (2) in. The interior vertical joints shall not exceed six (6) in.

Voids shall be thoroughly filled with *concrete.*
spalls, fully bedded in cement mortar.

*31-b. Backing shall be of *concrete.*
headers and stretchers, as specified in paragraphs 26 and 27, and heart of wall filled with concrete.

32. Where the wall will not admit of such arrangement, stone not less than four (4) ft. long shall be placed transversely in heart of wall to bond the opposite sides.

33. Where stone is backed with two courses, neither course shall be less than eight (8) in. thick.

Bond. 34. Bond of stone in face, back and heart of wall shall not be less than twelve (12) in. Backing shall be laid to break joints with the face stone and with one another.

Coping. 35. Coping stone shall be full size throughout, of dimensions indicated on the drawings.

36. Beds, joints and top shall be fine-pointed.

37. Location of joints shall be determined by the position of the bed plates, and be indicated on the drawings.

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[*] Paragraphs 31-a and 31-b are so arranged that either may be eliminated according to requirements. Optional clauses printed in italics.

Locks.

38. Where required, coping stone, stone in the wings of abutments, and stone on piers, shall be secured together with iron cramps or dowels, to the position indicated on the drawings.

BRIDGE AND RETAINING WALL MASONRY—RUBBLE STONE.

39. The stone shall be roughly squared, and laid in irregular courses. Beds shall be parallel, roughly dressed, and the stone laid horizontal to the wall. Face joints shall not be more than one (1) in. thick. Bottom stone shall be large, selected flat stone.

40. The wall shall be compactly laid, having at least one-fifth the surface of back and face headers arranged to interlock, having all voids in the heart of the wall thoroughly filled with *concrete.*
suitable stones and spalls, fully bedded in cement mortar.

ARCH MASONRY—ASHLAR STONE.

Arch Masonry, Ashlar Stone.

41. Voussoirs shall be full size throughout and dressed true to templet, and shall have bond not less than thickness of stone.

Dressing.

42. Joints of voussoirs and intrados shall be fine-pointed. Mortar joints shall not exceed three-eighths (3/8) in.

Face or Surface.

43. Exposed surface of the ring stone shall be *smooth.*
rock faced, with a marginal draft.

44. Number of courses and depth of voussoirs shall be indicated on the drawings.

45. Voussoirs shall be placed in the order indicated on the drawings.

Backing.

46. Backing shall consist of *concrete.*
large stone, shaped to fit the arch bonded to the spandrel and laid in full bed of mortar.

47. Where waterproofing is required, a thin coat of mortar or grout shall be applied evenly for a finishing coat, upon which shall be placed a covering of approved waterproofing material.

48. Centers shall not be struck until directed by the engineer.

Bench Walls, Piers, Spandrels, etc.

49. Bench walls, piers, spandrels, parapets, wing walls and copings shall be built under the specifications for Bridge and Retaining Wall Masonry, Ashlar Stone.

ARCH MASONRY—RUBBLE STONE.

Arch Masonry, Rubble Stone.

50. Voussoirs shall be full size throughout, and shall have bond not less than thickness of voussoirs.

Dressing.

51. Beds shall be roughly dressed to bring them to radial planes.

52. Mortar joints shall not exceed one (1) in.

Face or Surface.

53. Exposed surfaces of the ring stone shall be rock-faced, and edges pitched to true lines.

54. Voussoirs shall be placed in the order indicated on the drawings.

Backing.

55. Backing shall consist of *concrete.*
large stone, shaped to fit the arch, bonded to the spandrel, and laid in full bed of mortar.

56. Where waterproofing is required, a thin coat of mortar or grout shall be applied evenly for a finishing coat, upon which shall be placed a covering of approved waterproofing material.

57. Centers shall not be struck until directed by the engineer.

Bench Walls, Piers, Spandrels, etc.

58. Bench walls, piers, spandrels, parapets, wing walls and copings shall be built under the specifications for Bridge and Retaining Wall Masonry, Rubble Stone.

CULVERT MASONRY.

Culvert Masonry.

59. Culvert Masonry shall be laid in cement mortar. Character of stone and quality of work shall be the same as specified for Bridge and Retaining Wall Masonry, Rubble Stone.

Side Walls.

60. One-half the top stone of the side walls shall extend entirely across the wall.

Cover Stones.

61. Covering stone shall be sound and strong, at least twelve (12) in. thick, or as indicated on the drawings. They shall be roughly dressed to make close joints with each other, and lap their entire width at least twelve (12) in. over the side walls. They shall be doubled under high embankments, as indicated on the drawings.

End Walls, Coping.

62. End walls shall be covered with suitable coping, as indicated on the drawings.

DRY MASONRY.

Dry Masonry.

63. Dry Masonry shall include dry retaining walls and slope walls.

Retaining Walls.

64. Retaining Walls and Dry Masonry shall include all walls in which rubble stone laid without mortar is used for retaining embankments or for similar purposes.

Dressing.

65. Flat stone at least twice as wide as thick shall be used. Beds and joints shall be roughly dressed square to each other and to face of stone.

66. Joints shall not exceed three-quarters (¾) in.

Disposition of Stone.

67. Stone of different sizes shall be evenly distributed over entire face of wall, generally keeping the larger stone in lower part of wall.

68. The work shall be well bonded and present a reasonably true and smooth surface, free from holes or projections.

Slope Walls. 69. Slope walls shall be built of such thickness and slope as directed by the engineer. Stone shall not be used in this construction which does not reach entirely through the wall. Stone shall be placed at right angles to the slopes. The wall shall be built simultaneously with the embankment which it is to protect.

*SPECIFICATIONS FOR PLAIN AND REINFORCED CONCRETE AND STEEL REINFORCEMENT.

CONCRETE MATERIALS.

Cement. 1. The cement shall be Portland and shall meet the requirements of the standard specifications.

Fine Aggregates. 2. Fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, and passing when dry a screen having ¼-in. diameter holes; it shall preferably be of hard siliceous material, clean, free from dust, soft particles, vegetable loam or other deleterious matter, and not more than 6 per cent. shall pass a sieve having 100 meshes per linear inch.

3. The fine aggregate shall be of such quality that mortar composed of one part Portland cement and three parts fine aggregate by weight when made into briquettes shall show a tensile strength at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand.†

Coarse Aggregates. 4. Coarse aggregate shall consist of material such as crushed stone or gravel which is retained on a screen having ¼-in. diameter holes and having gradation of sizes from the smallest to the largest particles; it shall be clean, hard, durable and free from all deleterious matter. Aggregates containing dust, soft or elongated particles shall not be used.

Water. 5. The water used in mixing concrete shall be free from oil, acid, and injurious amounts of alkalies or vegetable matter.

STEEL REINFORCEMENT.

Manufacture. 6. Steel shall be made by the open-hearth process. Rerolled material will not be accepted.

7. Plates and shapes used for reinforcement shall be of structural steel only. Bars and wire may be of structural steel or high carbon steel.

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* Adopted, Vol. 11, 1910, pp. 962-967, 1019, 1020.

† This sand may be obtained from the Ottawa Silica Company at a cost of 2 cents per pound f. o. b. cars, Ottawa, Ill.

Schedule of Requirements.

8. The chemical and physical properties shall conform to the following limits:

Elements Considered.		Structural Steel.	High Carbon Steel.
Phosphorus, max....	Basic...............	0.04 per cent.	0.04 per cent.
	Acid...............	0.06 per cent.	0.06 per cent.
Sulphur, maximum........................		0.05 per cent.	0.05 per cent.
Ultimate tensile strength.		Desired	Desired
Pounds per square inch....................		60,000	88,000
Elong., min. % in 8″, Fig. 1..............		1,500,000* Ult. tensile str'gth	1,000,000 Ult. tensile str'gth
Character of Fracture......................		Silky	Silky or finely granular.
Cold Bends without Fracture...............		180° flat†	180° $d=4t$‡

*See paragraph 15. ‡"$d=4t$" signifies "around a pin whose diameter is four times the thickness of the specimen."

Yield Point.

9. The yield point for bars and wire, as indicated by the drop of the beam, shall be not less than 60 per cent. of the ultimate tensile strength.

Allowable Variations.

10. If the ultimate strength varies more than 4,000 lbs. for structural steel or 6,000 lbs. for high carbon steel, a retest shall be made on the same gage, which, to be acceptable, shall be within 5,000 lbs. for structural steel, or 8,000 lbs. for high carbon steel, of the desired ultimate.

Chemical Analyses.

11. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analysis shall be made from finished material, if called for by the railroad company, in which case an excess of 25 per cent. above the required limits will be allowed.

Form of Specimens.

12. Plates, Shapes and Bars: Specimens for tensile and bending tests for plates and shapes shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig. 1; or with both edges parallel; or they may be turned to a diameter of ¾-in. with enlarged ends.

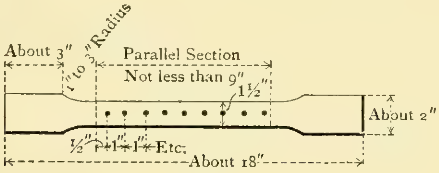

FIG. 1.

13. Bars shall be tested in their finished form.

Number of Tests.

14. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-in. and more in

thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled.

Modifications in Elongation.

15. For material less than 5/16-in. and more than ¾-in. in thickness the following modifications will be allowed in the requirements for elongation:

(a) For each 1/16-in. in thickness below 5/16-in. a deduction of 2½ will be allowed from the specified percentage.

(2) For each ⅛-in. in thickness above ¾-in., a deduction of 1 will be allowed from the specified percentage.

Bending Tests.

16. Bending tests may be made by pressure or by blows. Shapes and bars less than one inch thick shall bend as called for in paragraph 8.

Thick Material.

17. Test specimens one inch thick and over shall bend cold 180 degrees around a pin, the diameter of which, for structural steel, is twice the thickness of the specimen, and for high carbon steel, is six times the thickness of the specimen, without fracture on the outside of the bend.

Finish.

18. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects, and have a smooth, uniform and workmanlike finish.

Stamping.

19. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it, except that bar steel and other small parts may be bundled with the above marks on an attached metal tag.

Defective Material.

20. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected and shall be replaced by the manufacturer at his own cost.

21. Reinforcing steel shall be free from excessive rust, loose scale, or other coatings of any character, which would reduce or destroy the bond.

WORKMANSHIP.

Unit of Measure.

22. The unit of measure shall be the cubic foot. A bag containing not less than 94 lbs. of cement shall be assumed as one cubic foot of cement. Fine and coarse aggregates shall be measured separately as loosely thrown into the measuring receptacle.

Relation of Fine and Coarse Aggregates.

23. The fine and coarse aggregates shall be used in such relative proportions as will insure maximum density.

24. The proportions of materials for the different classes of concrete shall be as follows: **Proportions.**

Class.	Use.	Cement.	Aggregates.	
			Fine.	Coarse.

Note:—This blank to be filled for each contract.

25. For plain concrete, a proportion of 1:9 (unless otherwise specified) shall be used, i. e., one part of cement to a total of nine parts of fine and coarse aggregates measured separately; for example, 1 cement, 3 fine aggregate, 6 coarse aggregate.

26. For reinforced concrete a proportion of 1:6 (unless otherwise specified) shall be used, i. e., one part of cement to a total of six parts of fine and coarse aggregates measured separately.

27. The ingredients of concrete shall be thoroughly mixed to the desired consistency, and the mixing shall continue until the cement is uniformly distributed and the mass is uniform in color and homogeneous. **Mixing.**

28. The various ingredients, including the water, shall be measured separately, and the methods of measurement shall be such as to secure the proper proportions at all times. **Measuring Proportions.**

29. A machine mixer, preferably of the batch type, shall be used, wherever the volume of the work will justify the expense of installing the plant. The requirements demanded are that the product delivered shall be of the specified proportions and consistency and thoroughly mixed. **Machine Mixing.**

30. When it is necessary to mix by hand, the mixing shall be on a watertight platform of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. Batches shall not exceed one-half cubic yard each. The mixing shall be done as follows: The fine aggregate shall be spread evenly upon the platform, then the cement upon the fine aggregates, and these mixed thoroughly until of an even color. The water necessary to mix a thin mortar shall then be added and the mortar spread again. The coarse aggregates, which, if dry, shall first be thoroughly wetted down, shall then be added to the mortar. The mass shall then be turned **Hand Mixing.**

with shovels or hoes until thoroughly mixed and all the aggregate covered with mortar. Or, at the option of the engineer, the coarse aggregate may be added before, instead of after, adding the water.

Consistency.

31. The materials shall be mixed wet enough to produce a concrete of such consistency that it will flow into the forms and about the metal reinforcement, and which, on the other hand, can be conveyed from the place of mixing to the forms without separation of the coarse aggregate from the mortar.

Retempering.

32. Retempering mortar or concrete, i. e., remixing with water after it has partially set, will not be permitted.

Placing of Concrete.

33. Concrete after the completion of the mixing shall be handled rapidly to the place of final deposit, and under no circumstances shall concrete be used that has partially set before final placing.

34. The concrete shall be deposited in such a manner as will prevent the separation of the ingredients and permit the most thorough compacting. It shall be compacted by working with a straight shovel or slicing tool kept moving up and down until all the ingredients have settled in their proper place and the surplus water is forced to the surface. In general, except in arch work, all concrete must be deposited in horizontal layers of uniform thickness throughout.

35. In depositing concrete under water, special care shall be exercised to prevent the cement from floating away and to prevent the formation of laitance.

36. Before depositing concrete the forms shall be thoroughly wetted (except in freezing weather) or oiled, and the space to be occupied by the concrete cleared of debris.

37. Before placing new concrete on or against concrete which has set, the surface of the latter shall be roughened, thoroughly cleansed of foreign material and laitance, drenched and slushed with a mortar consisting of one part Portland cement and not more than two parts fine aggregate.

38. The faces of concrete exposed to premature drying shall be kept wet for a period of at least three days.

Freezing Weather.

39. Concrete shall not be mixed or deposited at a freezing temperature, unless special precautions, approved by the engineer, are taken to avoid the use of materials covered with ice crystals or containing frost and to provide means to prevent the concrete from freezing.

40. Where the concrete is to be deposited in massive work, clean, large stones, evenly distributed, thoroughly bedded and entirely surrounded by concrete, may be used, at the option of the engineer. **Rubble Concrete.**

41. Forms shall be substantial and unyielding and built so that the concrete shall conform to the designed dimensions and contours, and so constructed as to prevent the leakage of mortar. **Forms.**

42. The forms shall not be removed until authorized by the engineer.

43. For all important work, the lumber used for face work shall be dressed to a uniform thickness and width; shall be sound and free from loose knots and secured to the studding or uprights in horizontal lines.

44. For backings and other rough work undressed lumber may be used.

45. Where corners of the masonry and other projections liable to injury occur, suitable moldings shall be placed in the angles of the forms to round or bevel them off.

46. Lumber once used in forms shall be cleaned before being used again.

47. The reinforcement shall be carefully placed in accordance with the plans, and adequate means shall be provided to hold it in its proper position until the concrete has been deposited and compacted.

DETAILS OF CONSTRUCTION.

48. Wherever it is necessary to splice the reinforcement otherwise than as shown on the plans, the character of the splice shall be decided by the engineer on the basis of the safe bond stress and the stress in the reinforcement at the point of splice. Splices shall not be made at points of maximum stress. **Splicing Reinforcement.**

49. Concrete structures, wherever possible, shall be cast at one operation, but when this is not possible, the resulting joint shall be formed where it will least impair the strength and appearance of the structure. **Joints in Concrete.**

50. Girders and slabs shall not be constructed over freshly formed walls or columns without permitting a period of at least four hours to elapse to provide for settlement or shrinkage in the supports. Before resuming work, the tops of such walls or columns shall be cleaned of foreign matter and laitance.

51. A triangular-shaped groove shall be formed at the surface of the concrete at vertical joints in walls and abutments.

52. Except where a special surface finish is required, a spade or special tool shall always be worked between the concrete and the form to force back the coarse aggregates and produce a mortar face. **Surface Finish.**

Top Surfaces. 53. Top surfaces shall generally be "struck" with a straight edge or "floated" after the coarse aggregates have been forced below the surface.

Sidewalk Finish. 54. Where a "sidewalk finish" is called for on the plans, it shall be made by spreading a layer of 1:2 mortar at least ¾-in. thick, troweling the same to a smooth surface. This finishing coat shall be put on before the concrete has taken its initial set.

*DESIGN OF REINFORCED CONCRETE STRUCTURES.

Materials. (1) The materials and workmanship for reinforced concrete should meet the requirements of the "Specifications for Plain and Reinforced Concrete."

The concrete recommended for general use is a mixture of one part of cement to six parts of fine and coarse aggregates. A richer mixture will be found advantageous for special conditions.

Dead Load. (2) The dead load is to include the estimated weight of the structure and all other fixed loads and forces acting upon the structure.

Live Load. (3) The live load is to include all variable and moving loads or forces acting upon the structure in any direction.

Impact. (4) As the working stresses herein recommended are for static loads, the dynamic effect of moving loads is to be added to the live load stresses.†

Span Lengths. (5) The span length for beams and slabs is to be taken as the distance from center to center of the supports, but not to exceed the clear span plus the depth of beam or slab.

Internal Stresses. (6) The internal stresses are to be calculated upon the basis of the following assumptions:

(a) A plane section before bending remains plane after bending.

(b) The distribution of compressive stresses in members subject to bending is rectilinear.

(c) The ratio of the moduli of elasticity of steel and concrete is 15.

(d) The tensile stresses in the concrete are neglected in calculating the moment of resistance of beams.

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* Adopted, Vol. 11, 1910, pp. 967-969, 1019, 1020.

† The following formula is not recommended by the Committee, but is merely given as an illustration:

$$\text{Impact} = \frac{L}{L+D} L$$

L=Live load stress. D=Dead load stress.

(e) The initial stress in the reinforcement due to contraction or expansion in the concrete is neglected.

(f) The depth of a beam is the distance from the compressive face to the centroid of the tension reinforcement.

(g) The effective depth of a beam at any section is the distance from the centroid of the compressive stresses to the centroid of the tension reinforcement.

(h) The maximum shearing unit stress in beams is the total shear at the section divided by the product of the width of the section and the effective depth at the section considered. This maximum shearing unit stress is to be used in place of the diagonal tension stress in calculations for web stresses.

(i) The bond unit stress is equal to the vertical shear divided by the product of the total perimeter of the reinforcement in the tension side of the beam and the effective depth at the section considered.

(k) In concrete columns the concrete to a depth of 1½ in. is to be considered as a protective covering and is not to be included in the effective section.

Web Stresses.

*(7) "When the maximum shearing stresses exceed the value allowed for the concrete alone, web reinforcement should be provided to aid in carrying the diagonal tension stresses. This web reinforcement may consist of bent bars, or inclined or vertical members, attached to or looped about the horizontal reinforcement. Where inclined members are used, the connection to the horizontal reinforcement should be such as to insure against slip.

"In the calculation of web reinforcement when the concrete alone is insufficient to take the diagonal tension the concrete may be counted upon as carrying one-third of the shear. The remainder is to be provided for by means of metal reinforcement consisting of bent bars or stirrups, but preferably both. The requisite amount of such reinforcement may be estimated on the assumption that the entire shear on a section, less the amount assumed to be carried by the concrete, is carried by the reinforcement in a length of beam equal to its depth."

Shrinkage and Temperature Reinforcement.

(8) Reinforcement for shrinkage or temperature stresses, in amount generally not less than one-third of 1 per cent., and of a form which will develop a high bond resistance, should be placed and be well distributed near the exposed surface of the concrete.

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* The recommendations regarding web stresses are quoted from a report of the Joint Committee on Concrete and Reinforced Concrete.

Working Stresses.

(9) The following recommended working stresses, in pounds per square inch of section, are for use in concrete of such quality as to be capable of developing an average compressive strength of at least 2,000 lbs. per square in. when tested in cylinders 8 in. in diameter and 16 in. long and 28 days old, under laboratory conditions of manufacture and storage, the mixture being of the same consistency as is used in the field:

Structural steel in tension	14,000
High carbon steel in tension	17,000
Steel in compression, 15 times the compressive stress in the surrounding concrete.	
Concrete in bearing where the surface is at least twice the loaded area	700
Concrete in direct compression, without reinforcement on lengths not exceeding six times the least width	450
Concrete in direct compression with not less than 1 per cent. nor over 4 per cent. longitudinal reinforcement on lengths not exceeding twelve times the least width	450
Concrete in compression, on extreme fiber in cross bending	750
Concrete in shear, uncombined with tension or compression in the concrete	120
Concrete in shear, where the shearing stress is used as the measure of web stress	40
Note.—The limit of shearing stresses in the concrete, even when thoroughly reinforced for shear and diagonal tension, should not exceed	120
Bond for plain bars	80
Bond for drawn wire	40
Bond for deformed bars, depending upon form	100-150

* MONOLITHIC CONSTRUCTION.

DEFINITIONS.

Monolith of Concrete.—A single mass of concrete made without joints by a continuous operation of construction.

Monolithic Concrete Construction.—Monolithic concrete construction is the building of a single mass of concrete without joints by a continous operation.

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* Adopted, Vol. 12, 1911.

PRINCIPLES OF PRACTICE.

These conclusions are based upon the supposition that the structure is well designed and that the foundation is good:

(1) Monolithic concrete construction may be used without danger of cracking for abutments of any length that the working conditions will permit, provided the length does not exceed about three times the height.

(2) Where abutments with wing walls are not of monolithic construction, joints should be provided at the intersections of the wing walls and the body of the abutments.

(3) Reinforced concrete abutments may be built in units of any length that economic conditions will permit.

(4) Monolithic concrete construction may be used for arches where the conditions will permit, otherwise the arch ring should be constructed with radial joints.

COMMITTEE IX.

SIGNS, FENCES AND CROSSINGS.

*FENCES.

DEFINITIONS.

Fence.—Any barrier that serves to guard against unrestricted ingress and egress, especially a structure of posts, rails, wires, boards or pickets.

Fence Post.—An upright piece of timber, metal or other material used as a support for the attachment of the longitudinal members of the fence.

End Post.—A post at the end of a line or section of fence.

Intermediate Post.—A post placed between end posts.

Gate Post.—A post to which a gate is hung or latched.

Cleat.—A piece of wood or metal fastened transversely to the side of a post below the ground line to give it greater stability.

Brace.—A piece of timber or metal, in compression, placed diagonally between adjacent posts.

Stay.—A piece of timber, metal or other material, either vertical or inclined, serving the purpose of keeping the longitudinal wires the proper distance apart and stiffening the fence.

Stay Wire.—A stay formed of wire.

Fence Staple.—A metal device, in the shape of the letter "U" with ends sharpened, for fastening the longitudinal wires of the fence to the post.

Panel.—A section of fence between adjacent posts.

Brace Panel.—A panel in which a brace, or tie, or both, are introduced.

Top Wire.—The highest longitudinal wire of a fence.

Intermediate Wire.—A longitudinal wire located between top and bottom wires.

Bottom Wire.—The lowest longitudinal wire of a fence.

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*Adopted, Vol. 5, 1904, pp. 381, 382, 390, 446-451; Vol. 6, 1905, pp. 781, 782; Vol. 7, 1906, pp. 458, 479; Vol. 10, Part 1, 1909, pp. 885, 915-917; Vol. 11, Part 2, 1910, pp. 1230, 1231, 1246.

Tie Wire.—A wire in tension between any two posts.

Gate.—A movable barrier consisting of a frame or structure of wood, metal or other material for closing a passage or opening in a fence.

Gate Latch.—A device for fastening the free end of a gate to a gate post.

Gate Frame.—The sustaining parts of a gate, fitted and framed together, to which the other members are attached.

Gate Brace.—A piece of wood or metal serving the purpose of stiffening the frame of a gate.

Gate Hinge.—A device for attaching a gate to a post and upon which the gate swings.

Snow Fence.—A structure erected for the purpose of accumulating drifting snow.

*FENCES.

(1) The use of smooth wire in preference to barbed wire for railway fences is recommended.

(2) The use of a heavy smooth wire, or a plank at top of barbed wire fence, is recommended.

†SPECIFICATIONS FOR STANDARD RIGHT-OF-WAY FENCES, BUILT WITH WOODEN POSTS.

Classes.

1. Three classes of smooth wire fences may be used, the top wire of each to be 4 ft. 6 in. above the ground.

First-class Fence.

2. A first-class fence shall consist of nine longitudinal, smooth, coiled, galvanized steel wires; the top and bottom wires shall be No. 7 gage; intermediate and stay wires shall be No. 9 gage.

The spacing of the longitudinal wires shall be, commencing at the bottom: 3, 4, 5, 6, 7, 8, 9 and 9 in. The bottom wire shall be 3 in. above the ground, and the stay wires shall be spaced 12 in. apart.

Second-class Fence.

3. A second-class fence shall consist of seven longitudinal, smooth, coiled, galvanized steel wires; the longitudinal wires and stay wires shall be No. 9 gage.

The spacing of the longitudinal wires shall be, commencing at the bottom, 5, 6½, 7½, 9, 10 and 10 in. The bottom wire shall be 6 in. above the ground, and the stay wires shall be spaced 22 in. apart.

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* Adopted, Vol. 5, 1904, pp. 386, 390, 458, 459; Vol. 11, 1910, Part 2, pp. 1231, 1246.

† Adopted, Vol. 7, 1906, pp. 451-456, 478; Vol. 11, 1910, Part 2, pp. 1231-1234, 1246.

Third-class Fence.

4. A third-class fence shall consist of four longitudinal, smooth, coiled galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage.

The longitudinal wires shall be spaced 14 in. apart; the bottom wires shall be 12 in. above the ground, and the stay wires shall be spaced 22 in. apart.

MATERIAL.

Posts.

5. Posts shall be of .... They shall be straight and free from rot or other defects. Split or sawn posts may be used in localities where round posts are not economically available; their dimensions shall be at least equal to those hereinafter specified for round posts.

End Posts.

6. End or gate posts and intermediate bracing panel posts shall be at least 9 ft. long and 8 in. in diameter at the small end, or 8x8 in. if sawn.

Intermediate Posts.

7. Intermediate posts shall be 8 ft. long and not less than 4 in. in diameter at the small end.

Braces.

8. Braces for end posts, gate posts and intermediate brace panels shall be common fence posts or 4x4 in. common lumber, free from large knots, splits or rot.

Wire.

9. Woven wire fences shall be constructed of galvanized steel wire. Longitudinal wires shall be coiled.

*The elastic limit of all wire shall be at least .... lbs. for No. 9 gage wire, and .... lbs. for No. 7 gage wire.

*The ultimate tensile strength shall be at least .... lbs. for No. 9 gage wire, and .... lbs. for No. 7 gage wire. It must stand, without sign of fracture, winding tight around wire of the same size.

Stay Wires.

10. Stay wires shall be straight and of No. 9 gage.

Locks.

11. Locks or fastenings at the intersection of the longitudinal and stay wires shall be of such design as will prevent them from slipping either longitudinally or vertically.

Staples.

12. Staples used in posts shall be 1 in. long for hard wood and 1½ in. long for soft wood, and be made of No. 9 galvanized steel wire.

Galvanizing.

13. Galvanizing shall consist of an even coating of zinc, which shall withstand one-minute immersion tests in a solution of commercial sulphate of copper crystals and water, the specific gravity of which shall be 1.185 and whose temperature shall be from 60 to 70 degrees Fahrenheit. Immediately after each immersion the sample shall be washed in water and

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*The elastic limit and tensile strength of fence wire is under investigation, hence these have not been specified.

wiped dry. If the zinc is removed, or a copper-colored deposit is formed after the fourth immersion, the lot of material from which the sample is taken shall be rejected.

Manufacture.

14. The fence shall be so manufactured as not to remove the galvanizing nor impair the tensile strength of the wire.

ERECTION.

End Posts.

15. End posts shall be set vertical, at least 4 ft. in the ground, thoroughly tamped, braced and anchored.

Gate Posts.

16. Gate posts shall be set vertical and braced in a similar manner to the end posts.

Intermediate Posts.

17. Intermediate posts shall be set at least 3 ft. in the ground, and from 16½ to 33 ft. apart, depending upon the nature of the ground and the service required. Holes of full depth shall be provided for all end and gate posts, even if blasting must be resorted to. For intermediate posts, where rock is encountered, not more than two adjacent posts shall be set on sills 6x6 in. by 4 ft. long, braced on both sides by 2x6 in. braces, 3 ft. long. Holes shall be provided for all other posts.

Posts shall be set with the large end down.

Posts shall be set in perfect line on the side on which the wire is to be strung. After the fence is erected, the top of the posts shall be sawed off with a one-fourth pitch, the high side being next to the wire and 4 in. above it.

Anchoring.

18. End and gate posts shall be anchored by gaining and spiking two cleats to the sides of the posts, at right angles to the line of fence, one at the bottom and the other just below the surface of the ground. The cleat near the ground surface shall be put on the side of the post next the fence and the bottom cleat shall be put on the opposite side.

Intermediate posts set in depressions of the ground shall be anchored by gaining two cleats into the side near the bottom of the post, same to be properly spiked.

Cleats.

19. Cleats shall be 2 by 6 in. by 3 ft. long, of common lumber.

Bracing.

20. End, corner and gate posts shall be braced by using a common fence post or a piece of 4x4 in. common lumber, gained into the end corner or gate post, about 12 in. from the top, and into the next intermediate post, about 12 in. from the ground, and be securely spiked. A cable made of a double strand of No. 9 soft galvanized wire, looped around the end post at the ground line, and around the next intermediate post, about 12 in. below the top, shall be put on and twisted until the top of the next intermediate post is thrown back at least 2 in.

21. Longitudinal wires shall be stretched uniformly tight, and be parallel; stays shall be straight and vertical and be uniformly spaced. Stretching.

Wires shall be placed on the side of the post away from the track, except on curves, where they shall be so placed that the pull of the wires is against the post.

22. Staples shall be set diagonally with the grain of the wood, and be driven home tight. The top wire shall be double stapled. Stapling.

23. Approved bolt clamp splices or a wire splice made as follows may be used: In making wire splices the ends of the wires shall be carried 3 in. past the splicing tools and wrapped around both wires backward toward the tool for at least five turns, and after the tool is removed the space occupied by it shall be closed by pulling the ends together. Splicing.

*GALVANIZED WIRE FENCING.

(1) The rapid deterioration of modern woven galvanized fence wire is caused by the coating of zinc being too thin and of an uneven thickness. To procure better protection to the wire and a longer lived fence it is necessary to secure an increased uniform thickness of the zinc coating on the wire, and to insure that the galvanizing is intact after the wire has gone through the fence-weaving machines it is recommended that a second coat of zinc be applied to the fence after it is manufactured.

(2) The use of wire which has received a special galvanized coating to stand a test of four one-minute immersions in the standard copper sulphate solution, the galvanizing to be done preferably after weaving, is recommended.

†GATES FOR RIGHT-OF-WAY FENCES.

A hinged metal gate is recommended.

The width of farm gates should be not less than 12 ft., depending upon the size of agricultural machinery in use in the vicinity, or as required by the laws of the states through which the railroad operates. The minimum height of farm gates should be 4 ft. 6 in. from the surface of the roadway.

Farm gates should be hung so as to open away from the track, and, if hinged, swing shut by gravity.

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[*] Adopted, Vol. 7, 1906, pp. 456, 479; Vol. 11, Part, 2, 1911, pp. 1234, 1246; Vol. 12, 1911.

[†] Adopted, Vol. 8, 1907, pp. 528, 533; Vol. 10, Part 2, 1909, pp. 876, 910; Vol. 11, Part 2, 1910, pp. 1234, 1246.

TABLE SHOWING QUANTITY OF MATERIAL NEEDED FOR BARBED WIRE AND BOARD FENCES.

Spacing of Posts.	Posts. Posts—No. Required. Per Rod			Staples. Staples Required in Pounds—1 Strand of Wire. Per Rod. 1 in.									Nails. Nails Required in Pounds—1 Board. Per Rod. 8d Com.					
	Per Rod	Per 100	Per Mile	Per Rod. 1 in.	Per Rod. 1¼ in.	Per Rod. 1½ in.	Per 100 feet. 1 in.	Per 100 feet. 1¼ in.	Per 100 feet. 1½ in.	Per Mile. 1 in.	Per Mile. 1¼ in.	Per Mile. 1½ in.	Per Rod. 8d Com.	Per Rod. 10d Com.	Per 100 feet. 8d Com.	Per 100 feet. 10d Com.	Per Mile. 8d Com.	Per Mile. 10d Com.
8	2.06	12.50	660.0	0.02	0.03	0.03	0.12	0.15	0.18	6.41	7.96	9.57	0.07	0.10	0.39	0.60	20.7	31.5
10	1.65	10.00	528.0	0.02	0.02	0.03	0.10	0.12	0.15	5.13	6.36	7.66	0.07	0.11	0.41	0.64	22.0	33.5
12	1.38	8.33	440.0	0.02	0.02	0.02	0.08	0.10	0.13	4.28	5.30	6.38	0.06	0.09	0.35	0.53	18.3	28.0
14	1.18	7.16	378.0	0.02	0.02	0.02	0.07	0.09	0.11	3.68	4.56	5.48	0.05	0.08	0.30	0.46	15.7	24.0
16	1.03	6.25	330.0	0.01	0.02	0.02	0.06	0.08	0.10	3.20	4.00	4.78	0.05	0.07	0.26	0.40	13.7	21.0
16½	1.00	6.06	320.0	0.01	0.02	0.02	0.06	0.08	0.09	3.11	3.86	4.64						
18	0.92	5.57	294.0	0.01	0.02	0.02	0.06	0.07	0.08	2.86	3.54	4.26						
20	0.83	5.00	264.0	0.01	0.01	0.02	0.05	0.06	0.07	2.56	3.18	3.83						
22	0.75	4.54	240.0	0.01	0.01	0.02	0.05	0.06	0.07	2.34	2.89	3.48						
24	0.69	4.17	220.0	0.01	0.01	0.01	0.04	0.05	0.06	2.14	2.66	3.19						
26	0.64	3.86	204.0	0.01	0.01	0.01	0.04	0.05	0.06	2.00	2.46	2.96						
28	0.59	3.58	189.0	0.01	0.01	0.01	0.04	0.04	0.06	1.84	2.28	2.74						
30	0.55	3.34	176.0	0.01	0.01	0.01	0.03	0.04	0.05	1.71	2.12	2.55						

NOTE – The quantity of nails required is figured on a basis of two nails to a board to each post.

Where posts are 8 feet apart it is figured to use a board 16 feet long.

BARBED WIRE FENCE.

Style of Wire.	Gage of Strand.	Spacing of Barbs.	Weight in Pounds. Per Rod	Weight in Pounds. Per 100 ft.	Weight in Pounds. Per Mile
Baker's Perfect Regular or Cattle, 2 pt	12½	5 in.	0.88	5.31	280.0
“ “ Thickset or Hog, 2 pt	12½	3 “	0.97	5.87	310.0
Ellwood, Regular or Cattle, 4 pt	12½	5 “	0.94	5.68	300.0
“ Thickset or Hog, 2 pt	12½	3 “	1.00	6.06	320.0
“ Glidden, Regular or Cattle, 2 pt	12½	5 “	0.92	5.60	295.0
“ “ Thickset or Hog, 2 pt	12½	3 “	0.99	5.97	315.0
“ Junior, Regular or Cattle, 2 pt	12½	5 “	0.88	5.31	280.0
“ “ Thickset or Hog, 2 pt	12½	3 “	0.94	5.68	300.0
American Glidden, Regular or Cattle, 2 pt	12	5 “	1.00	6.06	320.0
“ “ Thickset or Hog, 2 pt	12	3 “	1.08	6.54	345.0
Lyman, Regular or Cattle, 4 pt	12	5 “	1.14	6.92	365.0
“ Thickset or Hog, 4 pt	12	3 “	1.25	7.58	400.0
Waukegan, Regular or Cattle, 2 pt	12½	5 “	0.87	5.26	277.5
“ Thickset or Hog, 2 pt	12½	3 “	0.94	5.68	300.0

BOARD FENCE.

Size of Board.	Ft. B. M. Per Rod	Ft. B. M. Per 100 ft.	Ft. B. M. Per Mile.
1 in. x 4 in.	5.50	33.33	1760.0
1 x 6	8.25	50.00	2640.0
1 x 8	11.00	66.67	3520.0
1 x 10	13.75	83.34	4400.0
1 x 12	16.50	100.00	5280.0

NOTE—The material given on the above tables is for one wire or one board high, in order that the material for fences of any number of wires or boards may be figured for different styles of wire and different sizes of boards.

Number of pounds of nails and staples is figured on an allowance of 5 per cent. to 100 per cent. for loss.

SMOOTH STEEL WIRES.

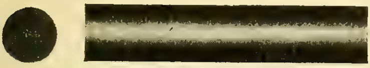
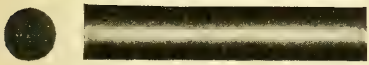
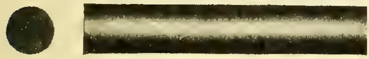
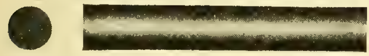
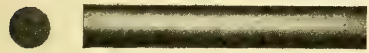
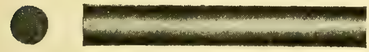
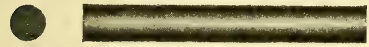
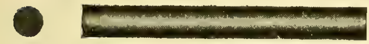
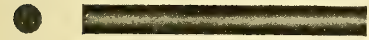
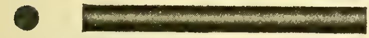
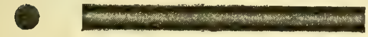
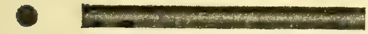
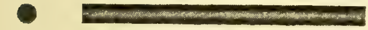
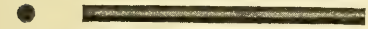
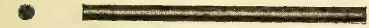
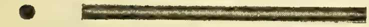
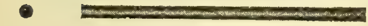
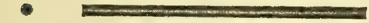
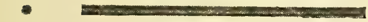
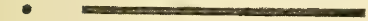
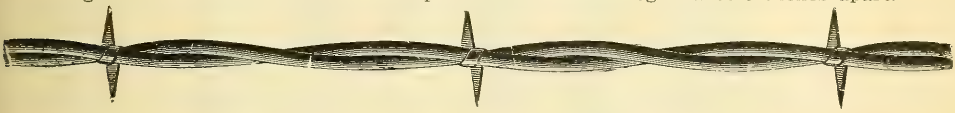
Cuts showing exact sizes of No. 1 to No. 20 gage steel wire by American Steel & Wire Company gage.	Gage.	Lbs. to Mile	Feet to 1 lb.
	1	1121	4.71
	2	968	5.45
	3	833	6.34
	4	707	7.47
	5	599	8.81
	6	514	10.28
	7	439	12.05
	8	367	14.37
	9	306	17.24
	10	255	20.70
	11	202	26.18
	12	154	34.25
	13	118	44.64
	14	89	59.17
	15	72	73.00
	16	55	95.24
	17	41	129.87
	18	31	172.11
	19	24	222.22
	20	17	312.50

TABLE OF COMPARATIVE SIZES OF WIRE GAGE—IN DECIMALS OF AN INCH.

No. of Wire Gauge.	A. S. & W. Co., or Washburn & Moen.	Birmingham, or Stubb's.	Brown & Sharpe.	English Legal Standard.	Old English, or London.
000000	.460	. . .	. . . . . .	.464	. . . . .
00000	.430	. . . .	. . . . . .	.432	. . . . .
0000	.393	.454	.46000	.400	.4540
000	.362	.425	40964	.372	.4250
00	.331	.380	.36480	.348	.3800
0	.307	.340	.32495	.324	.3400
1	.283	.300	.28930	.300	.3000
2	.263	.284	.25763	.276	.2840
3	.244	.259	.22942	.252	.2590
4	.225	.238	.20431	.232	.2380
5	.207	.220	.18194	.212	.2200
6	.192	.203	.16202	.192	.2030
7	.177	.180	.14428	.176	.1800
8	.162	.165	.12849	.160	.1650
9	.148	.148	.11443	.144	.1580
10	.135	.134	.10189	.128	.1340
11	.120	.120	.09074	.116	.1200
12	.105	.109	.08081	.104	.1090
13	.092	.095	.07196	.092	.0950
14	.080	.083	.06408	.080	.0830
15	.072	.072	.05707	.072	.0720
16	.063	.065	.05082	.064	.0650
17	.054	.058	.04526	.056	0580
18	.047	.049	.04030	.048	.0490
19	.041	.042	.03589	.040	.0400
20	.035	.035	.03196	.036	.0350
21	.032	.032	.02846	.032	.0315
22	.028	.028	.02535	.028	.0295
23	.025	.025	.02257	.024	.0270
24	.023	.022	.02010	.022	.0250
25	.020	.020	.01790	.020	.0230
26	.018	.018	.01594	.018	.0205
27	.017	.016	.01419	.0164	.01875
28	.016	.014	.01264	.0148	.01650
29	.015	.013	.01126	.0136	.01550
30	.014	.012	.01002	.0124	.01375
31	.0135	.010	.00893	.0116	.01225
32	.0130	.009	.00795	.0108	.01125
33	.0110	.008	.00708	.0100	.01025
34	.0100	.007	.00630	.0092	.00950
35	.0095	.005	.00561	.0084	.00900
36	.0090	.004	.00500	.0076	.00750
37	0085	. . . .	.00445	.0068	.00650
38	.0080	. . . .	.00396	.0060	.00575
39	.0075	. . . .	.00353	.0052	.00500
40	·0070	. . . .	.00314	.0048	.00450

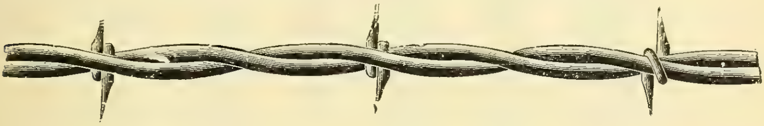
BAKER PERFECT. TWO POINT.

Flat barbs, short and sharp.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



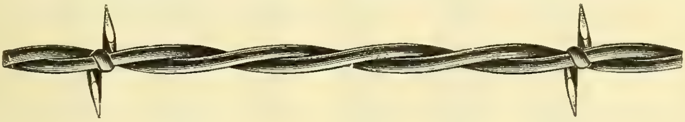
ELLWOOD JUNIOR, TWO POINT.

Half-round Barbs, short and sharp.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



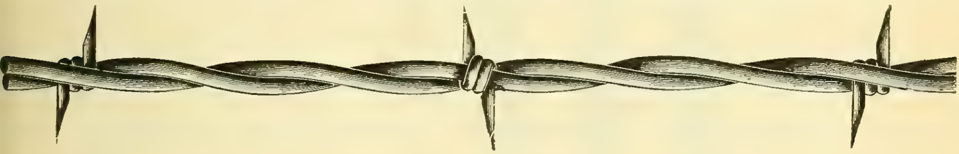
WAUKEGAN. TWO POINT.

Half-round Barbs, short and sharp.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



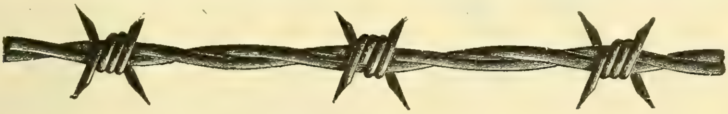
AMERICAN GLIDDEN. TWO POINT.

Round Barbs.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



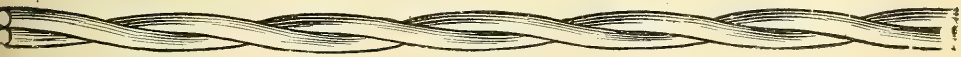
LYMAN, FOUR POINT.

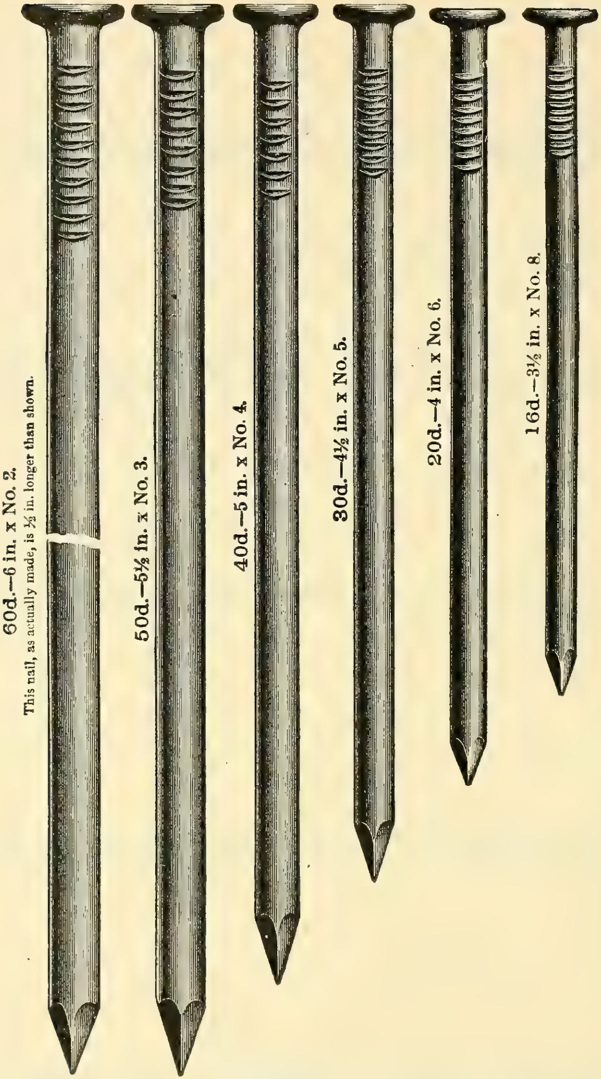
Round Barbs.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



BARBLESS FENCING.

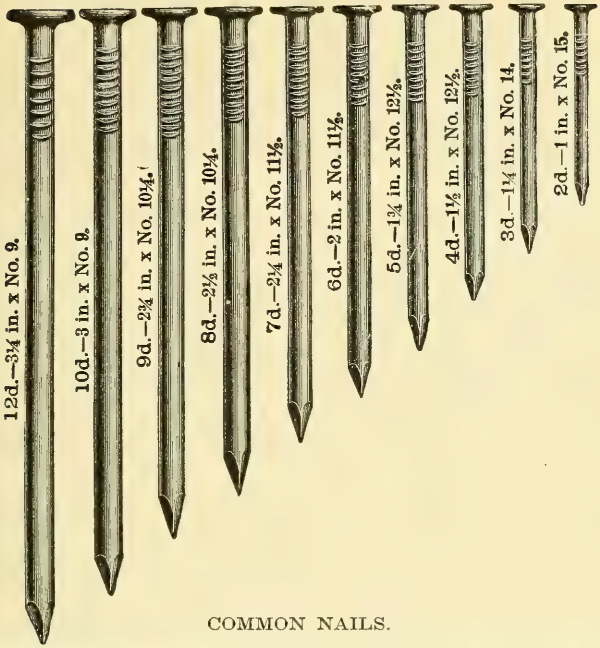
Two-Ply Twisted Galvanized Barbless Fencing. Sizes 11 to 14 inclusive.
3-Ply, 4-Ply, 5-Ply and 6-Ply Twisted Barbless Fencing. Sizes 7 to 14 inclusive.




60d.—6 in. x No. 2.
This nail, as actually made, is ½ in. longer than shown.
50d.—5½ in. x No. 3.
40d.—5 in. x No. 4.
30d.—4½ in. x No. 5.
20d.—4 in. x No. 6.
16d.—3½ in. x No. 8.

COMMON NAILS.

Size.	Length and Gage.		Approximate No. to lb.
16d.	3½ inch	No. 8	49
20d.	4 "	" 6	31
30d.	4½ "	" 5	24
40d.	5 "	" 4	18
50d.	5½ "	" 3	14
60d.	6 "	" 2	11


12d.—3¼ in. x No. 9.
10d.—3 in. x No. 9.
9d.—2¾ in. x No. 10¼.
8d.—2½ in. x No. 10¼.
7d.—2¼ in. x No. 11½.
6d.—2 in. x No. 11½.
5d.—1¾ in. x No. 12½.
4d.—1½ in. x No. 12½.
3d.—1¼ in. x No. 14.
2d.—1 in. x No. 15.

COMMON NAILS.

Size.	Length and Gage.		Approximate No. to lb.
2d.	1 inch	No. 15	876
3d.	1¼ "	" 14	568
4d.	1½ "	" 12½	316
5d.	1¾ "	" 12½	271
6d.	2 "	" 11½	181
7d.	2¼ "	" 11½	161
8d.	2½ "	" 10¼	106
9d.	2¾ "	" 10¼	96
10d.	3 "	" 9	69
12d.	3¼ "	" 9	63

1¼ in.

1½ in.

FENCE STAPLES.

Length.	No. to lb.
⅞	120
1	108
1⅛	96
1¼	87
1½	72
1¼	65
2	58

*CONCRETE FENCE POSTS.

(1) Concrete fence posts will heave very little and in most cases not at all; posts set from two to five years ago are still in almost perfect alinement.

(2) They appear sufficiently strong for all practical purposes after having been properly cured and set.

A cedar post of dimensions identical with the average concrete post would weigh about one-fourth as much and is about four times as strong when new, but this only brings out the fact that the cedar post is stronger than necessary and that the concrete post with its lesser strength is yet strong enough to serve its purpose, and has a longer life.

(3) The claim that a concrete post reinforced with steel forms a lightning protector appears reasonable.

(4) They resist the action of fire and decay, and will not float and cannot be displaced as easily as wood.

(5) They must be handled carefully in loading and unloading, and be well cured before being set.

(6) They are much heavier than wood posts and the cost of distributing and setting is about 25 per cent. greater.

(7) Concrete fence posts are recommended for railroad fences.

†SNOW FENCES, SNOWSHEDS AND RECOMMENDED METHODS FOR SNOW REMOVAL.

Snow is carried by the wind close to the surface of the ground and is deposited in railway cuts on account of the eddies which they cause in the wind. The function of the snow fence is to form artificial eddies on the windward side of the cut at sufficient distance to cause the snow to deposit between the snow fence and the cut.

The location of the drift or eddy depends upon the form of the fence. A tight fence of sufficient height causes the snow to accumulate on the windward side of the fence; an open fence causes the snow to accumulate principally on the leeward side. The distance between the fence and the drift depends upon the height of the fence, the width

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* Adopted, Vol. 10, Part 2, 1910, pp. 898, 916, 917; Vol. 11, Part 2, 1911, pp. 1243, 1244, 1246.

† Adopted, Vol. 10, Part 2, 1909, pp. 877, 881-897, 915-917; Vol. 11, Part 2, 1910, pp. 1239-1241, 1246; Vol. 12, 1911.

of the openings between the boards, the velocity of the wind and the character of the snow.

The character of the snow fence and its location for the protection of a given point depends largely upon local conditions, some of which can only be determined by experiment, and for this purpose portable snow fence is recommended.

Where local conditions permit, a permanent snow fence located on the right-of-way line is most economical.

Where permanent wooden fences are used, the boards should be laid close, where the right-of-way is 50 ft. or less from the center of the track; for greater distances, space should be provided between the boards, and at 100 ft. distance, 50 per cent. of the fence should be open space.

The height of permanent board fence depends upon the probable amount of snow. The maximum height, however, should be 10 ft.

In most cases local conditions require the use of a portable snow fence. These fences are usually erected in the fields adjoining the right-of-way. They should be set on the windward side of the track at right angles to the prevailing winds; to provide for variations in the direction of the wind it is sometimes necessary to set the panels in crescent form. For ordinary conditions one line of fence is sufficient. The quantity of snow sometimes requires the use of three or four lines of portable snow fences set parallel and spaced about 100 ft. apart. These fences should be removed in the spring so as not to interfere with farming operations.

Hedge fences should be used where the quantity of snow is not too great, and where local conditions, including the economic feature, permit. Properly maintained hedge fences are effective in beautifying the right-of-way.

Stone walls should be used for snow fences where suitable stones for dry masonry walls are available.

Temporary snow fences should be constructed of ties, laid in the form of worm fences.

Railways in Northern countries should have the track raised about 2 ft. above the general level of the ground, and for cuts less than 4 ft. a flat slope of 4 to 1 should be given to both sides of the cut.

In construction of new railways, or in grade revision, or trestle filling on existing railways in snow districts, the material should be taken from the sides of cuts. A steam shovel cut on each side is most effective in providing a place for snow to accumulate for ordinary snow conditions for cuts up to 20 ft. in depth.

Salt should be used on switches only during that portion of the winter when the snow melts in daytime and freezes at night.

Where exhaust steam is available it should be carried about 12 in. beneath the surface of the ground at points where the accumulation of the ice requires frequent removal during the winter.

SNOW PLOWS.

Rotary snow plows are necessary for quick removal of snow where the depth of the drift exceeds 6 ft. and its length exceeds 300 ft., or where the natural snowfall has filled deep cuts which cannot be removed by the push plow. Rotary snow plows are sometimes used to advantage in the removal of snow slides in mountain districts.

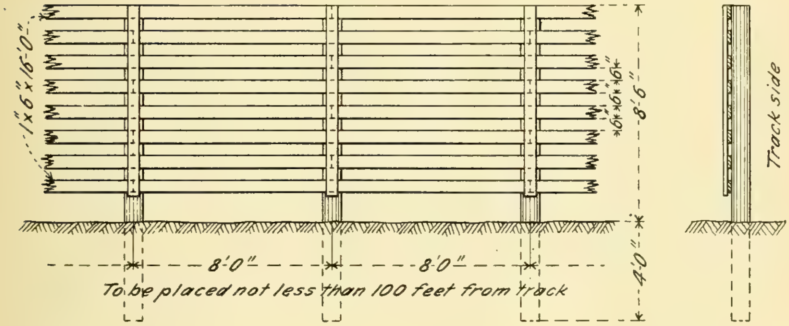
Push plows should be used for a level fall of snow and minor drifts, whenever the depth is too great to be removed by snow flangers. Snow flangers should be used for the removal of snow where the depth is less than 6 in. over the top of the rail.

SNOW SHEDS.

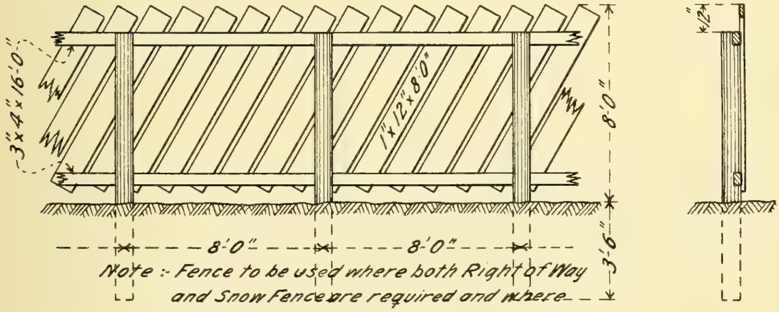
Snow sheds are expensive to construct and expensive to maintain, and the railway should be so located, if possible, as to make their construction unnecessary. Their use should be confined to localities which require protection from mountain snow slides, and they should be constructed of permanent material.

PERMANENT SNOW FENCE

OPEN BOARDING.

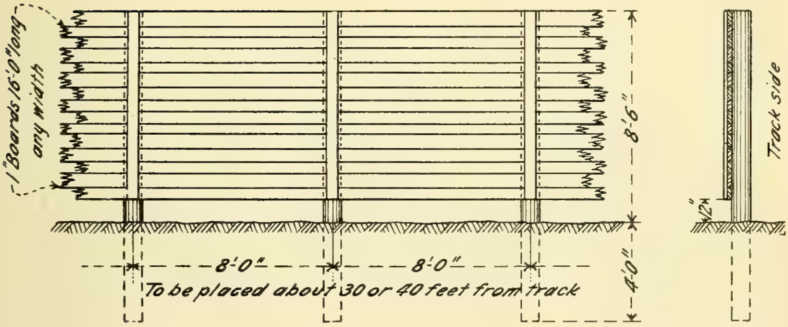

1"x6"x16'0"
9"×9"×9"
8'6"
8'0"
8'0"
4'0"
Track side

To be placed not less than 100 feet from track


3"x4"x16'0"
1"x12"x8'0"
8'0"
12"
8'0"
8'0"
3'6"

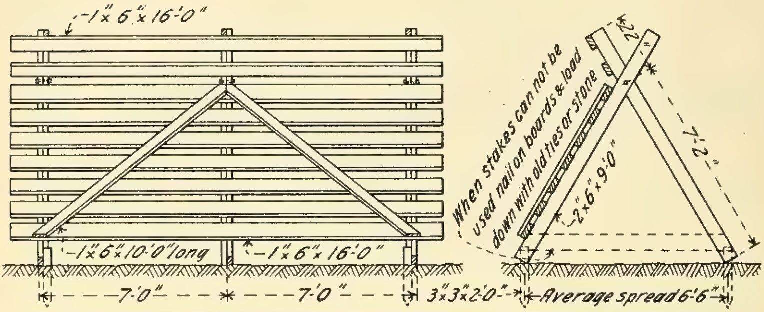
Note :- Fence to be used where both Right of Way and Snow Fence are required and where the Right of Way width is such that the Permanent form will be effective.

CLOSE BOARDING.


1" Boards 16'0" long any width
8'6"
12"
8'0"
8'0"
4'0"
Track side

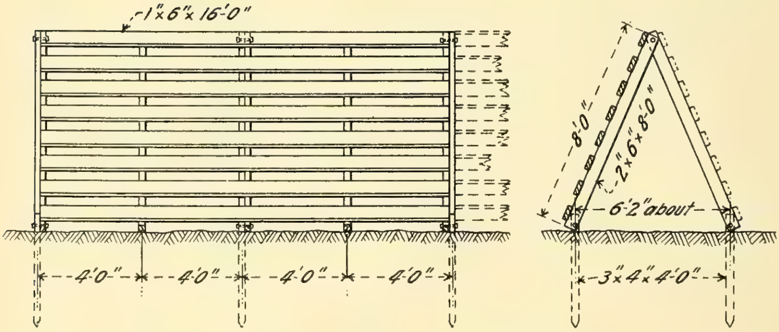
To be placed about 30 or 40 feet from track

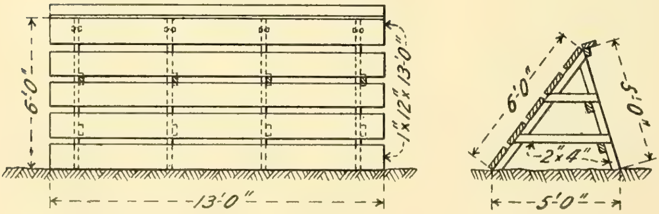
PORTABLE SNOW FENCE.


1" x 6" x 16'-0"
1" x 6" x 10'-0" long
1" x 6" x 16'-0"
7'-0"
7'-0"
3" x 3" x 2'-0"
Average spread 6'-6"
When stakes can not be used nail on boards & load down with old ties or stone
2" x 6" x 9'-0"
7'-2"
2½"

To be placed not less than 100 feet from track

Length of Section may be reduced to 14 ft. when cost per lin. ft is not increased.


1" x 6" x 16'-0"
4'-0"
4'-0"
4'-0"
4'-0"
8'-0"
2" x 6" x 8'-0"
6'-2" about
3" x 4" x 4'-0"


6'-0"
1" x 12" x 13'-0"
13'-0"
6'-0"
2" x 4"
5'-0"
5'-0"

*SURFACE CATTLE-GUARDS.

DEFINITIONS.

CATTLE-GUARD.—A barrier placed at the intersection of a wing-fence with a railway track to prevent the passage of live stock along the track.

APRON.—The flaring panel of fence set parallel with the track between the cattle-guard and the wing-fence.

WING-FENCE.—The line of fence making connection between the apron of the cattle-guard and the right-of-way or line fence.

SECTION.—A group of slats or strips which go to make up a surface cattle-guard.

FILLER.—A piece of timber, metal or other material placed between the slats composing a section of a surface cattle-guard to space and stiffen them.

SLAT.—Strip of wood or metal used to make up sections of a cattle-guard.

DESIGN OF GUARD.

The use of the surface cattle-guard in preference to the pit guard is recommended.

†GENERAL REQUIREMENTS.

(1) The cattle-guard should be so constructed as to avoid projecting surfaces liable to be caught by dragging brake or other rigging.

(2) It should be of such construction so as not to endanger employes who pass over it in the discharge of their duties.

(3) It should be effective against all live stock, but have no parts which would catch and hold animals endeavoring to pass.

(4) It should be reasonable in first cost, durable and easily applied and removed, so as to permit repairs of track at minimum expense.

(5) It should not rattle during the passage of trains.

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* Adopted, Vol. 5, 1904, pp. 386, 390, 458, 459; Vol. 10, Part 2, 1909, pp. 885, 915; Vol. 11, Part 2, 1910, pp. 1231, 1246.

† Adopted, Vol. 5, 1904, pp. 387, 390, 459, 461, 462; Vol. 11, Part 2, 1911, pp. 1231, 1246.

COMMITTEE X.

SIGNALS AND INTERLOCKING.

* DEFINITIONS.

Definitions from Standard Code of The American Railway Association.

Block.—A length of track of defined limits, the use of which by trains is controlled by block signals.

Block Station.—A place from which block signals are operated.

Fixed Signal.—A signal of fixed location, indicating a condition affecting the movement of a train.

Block Signal.—A fixed signal controlling the use of a block.

Home Block Signal.—A fixed signal at the entrance of a block, to control trains in entering and using said block.

Distant Block Signal.—A fixed signal used in connection with a home (and advance) block signal, to regulate the approach thereto.

Advance Block Signal.—A fixed signal used in connection with a home block signal to sub-divide the block in advance.

Block System.—A series of consecutive blocks.

Manual Block System.—A block system in which the signals are operated manually.

Controlled Manual Block System.—A block system in which the signals are operated manually, and so constructed as to require the co-operation of the signalmen at both ends of the block to display a clear or a caution block signal.

Automatic Block System.—A block system in which the signals are operated by electric, pneumatic, or other agency actuated by a train or by certain conditions affecting the use of a block.

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* Adopted, Vol. 7, 1906, pp. 482, 522-524.

Absolute Block System.—One in which only one train at a time is permitted to occupy the block.

Arm Sweep.—The segment of a circle defining the limits of movement of the arm.

Arm.—A movable arm pivoted to the signal mast, the positions of which give the indications.

Blade.—That part of the arm which, by its form and positions, gives the day signal indications.

Bracket Mast.—A mast mounted on a bracket post.

Bracket Post.—An arrangement of main post with cross-beam, upon which is placed one or two masts for carrying the signal arms, the arrangement of masts determining which track or tracks the signals govern.

Bridge Mast.—A mast mounted on a signal or other overhead bridge.

Chain Wheel.—A device used for changing the direction of a wire line.

Compensator.—A device placed in a pipe or wire line for automatically maintaining a constant length of line under changes of temperature.

Crank.—A device used for changing the direction of a pipe line.

Crank Stand.—A frame in which cranks are supported.

Cross Locking.—A variable shaped block or bar running crosswise of the interlocking machine, actuated by the movements of the locking dog, and by means of which connection is effected between the levers.

Detector Bar.—A bar placed at a switch alongside of and normally below the top of rail, operated in connection with a facing point lock, derailing device or crossing switch, or so that its operation, and consequently that of the lock, will be prevented by the presence of any of the wheels of the train.

Electric Slot.—An appliance for automatically disengaging the signal arm connection from its actuating lever, returning signal arm to "stop."

Foundation.—A fixed support, usually set in the ground, for carriers, cranks, compensators, wheels, signals and other like devices.

Interlocking Machine.—The primary operating or controlling mechanism of an interlocking plant, placed in the interlocking station, and in which the interlocking feature is effected.

Interlocking Plant.—An arrangement of switch, lock and signal appliances so interconnected or interlocked that one movement must succeed another in a predetermined order.

Interlocking Signals.—The fixed signals of an interlocking plant.

Interlocking Station.—A place from which an interlocking plant is operated.

Jaw.—A device attached to pipe line for connecting same with machine, crank, compensator, or any other device designed for pipe operation.

Leadout.—A combination of cranks, wheels, rocking shafts, pipes and wire, etc., inside and outside of interlocking station by which connections are made between machine and pipe runs.

Lever.—That part of an interlocking machine whose movement effects the operation of its function.

Locking.—A combination of locking dogs and cross-locking or locking dogs and tappets by means of which interconnection is effected between the levers and the order of movement determined.

Locking Bar.—A bar running lengthwise in the interlocking machine to which the locking dogs are attached.

Locking Dog.—A variously shaped block attached to locking bar and through which the interlocking is accomplished.

Mast.—The upright to which the signals are directly attached.

Operated Unit.—A switch, signal, lock or other device in signaling, operated by a lever or other operating means.

Permissive Block System.—One in which two or more trains may occupy a block at the same time.

Pipe Carrier.—A frame with roller support for the pipe line.

Pipe Run.—An assemblage of pipe lines of an interlocking plant, with their carriers and foundations, in a common course.

Rocking Shaft.—A rotating shaft with arms, used for changing the line of motion from one plane to another, perpendicular to the axis of the shaft; also used at slip switches for operating several detector bars and locks.

Route.—A course or way taken by a train in passing from one point to another, especially a customary or predetermined course, or any one of several possible combinations of turnouts or crossovers by which a train may travel between two places.

Screw Jaw.—A threaded jaw used for the purpose of adjustment.

Semaphore Signal.—A device consisting of a movable arm attached to a mast, the indications being given by the position of the arm.

Semaphore Spectacle.—That part of a signal which holds the colored glasses and to which the blade may be attached.

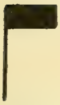
Tappet.—*a.* (In machine with vertical locking.) A bar operated directly or indirectly by the lever or lever latch, which actuates or drives the locking bars and is locked by them.

b. (In machine with horizontal locking.) A pivot or swing dog attached to the locking bar, and actuated or locked by the cross-locking.

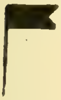
Wire Carrier.—A frame with roller support for the wire line.

Wire Run.—An assemblage of wire lines of an interlocking plant, with their carriers and foundations, in a common course.

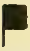
* CONVENTIONAL SIGNS—SYMBOLS.



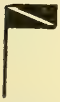
Two-Position Mechanical Interlocking Home Signal.



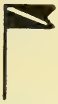
Two-Position Mechanical Interlocking Distant Signal.



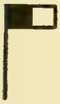
Two-Position Mechanical Interlocking Dwarf Signal.



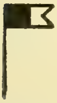
Three-Position Mechanical Interlocking Home Signal.



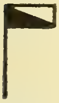
Three-Position Mechanical Interlocking Distant Signal.



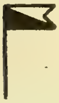
Two-Position Semi-Automatic Interlocking Home Signal.



Two-Position Semi-Automatic Interlocking Distant Signal.



Three-Position Semi-Automatic Interlocking Home Signal.



Three-Position Semi-Automatic Interlocking Distant Signal.

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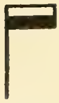
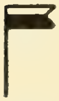
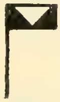
* Adopted, Vol. 7, 1906, pp. 515-521, 548.



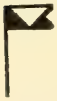
Two-Position Slotted Interlocking Home Signal.



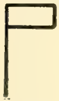
Two-Position Slotted Interlocking Distant Signal.



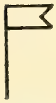
Three-Position Slotted Interlocking Home Signal.



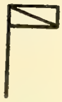
Three-Position Slotted Interlocking Distant Signal.



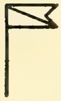
Two-Position Automatic Home Signal.



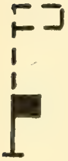
Two-Position Automatic Distant Signal.



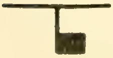
Three-Position Automatic Home Signal.



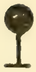
Three-Position Automatic Distant Signal.



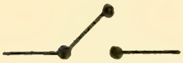
Ground Route Signal.



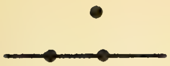
Suspended Dwarf Signal.



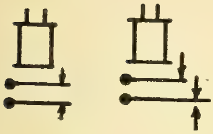
Pot Signal.



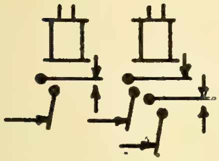
Circuit Controller on Lever, Mechanical Interlocker, normally open.



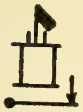
Circuit Controller on Lever, Mechanical Interlocker, normally closed.



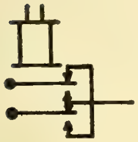
Direct Current Relays, common.



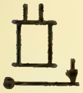
Direct Current Relays, polarized.



Direct Current Relays, Semaphore Indicator.

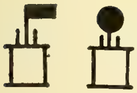


Direct Current Relays, pole changing.

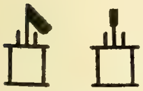


Direct Current Relays, differential.

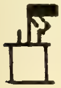
INTERLOCKING OR BLOCK STATION INDICATORS.



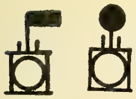
Semaphore, Disc. Stop When Energized.



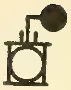
Semaphore, Disc. Proceed When Energized.



Signal Repeater. Stop or Proceed When Energized.

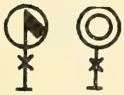


Semaphore, Disc, with Bell.

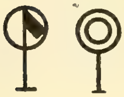


Disappearing Disc.

SWITCH INDICATORS.

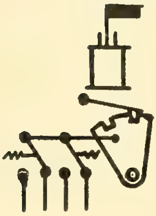


Semaphore, Disc, with Switchbox.

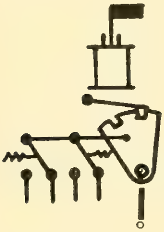


Semaphore, Disc, without Switchbox.

ELECTRIC LOCK AND INDICATING CIRCUIT CONTROLLER.

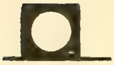


For Mechanical Interlocking Machine, Operated from Quadrant of Lock.

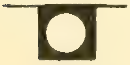


Hand Operated.

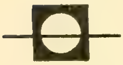
BATTERY HOUSE.



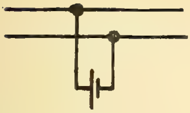
Above Surface.



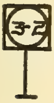
Below Surface.



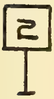
Half Above Surface.



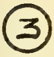
Track Battery.



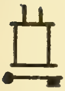
Battery Chute, Relay Box and Post. (Left figure indicates capacity of chute; right figure indicates capacity of Relay Box.)



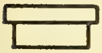
Relay Box and Post. (Figure indicates capacity.)



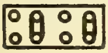
Battery Chute. (Figure indicates capacity.)



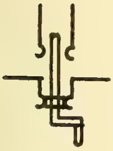
Electric Lock.



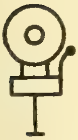
Battery Cupboard.



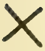
Switch Box.



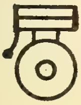
Spring Screw Release.



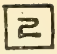
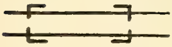
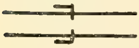
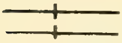
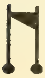
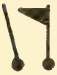
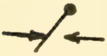
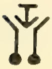
Switch Bell.



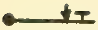
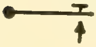
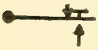
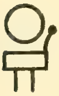
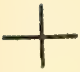
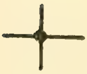
Switch Box Location.

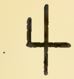


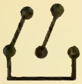
Crossing Bell.

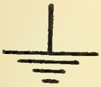
	Relay Box. (Figure indicates capacity.)
	Short Track Circuit.
	Circuit on Right only, Insulated Joints.
	Circuits Right and Left.
	Signal Circuit Breaker (Closed).
	Signal Circuit Breaker (Open).
	Circuit Switch.
	Floor Push.

SPRING HAND KEYS.

	Normally Closed.
	Normally Open.
	Normally Open or Closed.
	Bell.
	Wires Cross.
	Wires Join.


Lightning Arrester.


Pole Changing Switch.


Ground.

* TRAIN-ORDER SIGNALS.

The American Railway Association's third and fourth requisites of installation of interlocking plants are: (3) "Signals if practicable (to be) either over or upon the right of and adjoining the track to which they refer." (4) "Semaphore arms that govern (to be) displayed to the right of the signal mast as seen from an approaching train."

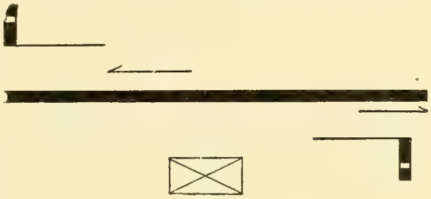


FIG. 1.

It is recommended that these two requisites be adopted with reference to *fixed* train-order signals for all number of tracks from one up, as illustrated in Figs. 1 and 2.

Where it may be deemed advisable, for special reasons, to use a bracket post, no more than two uprights should be placed on the bracket. One of these uprights may be a stub to indicate a track not

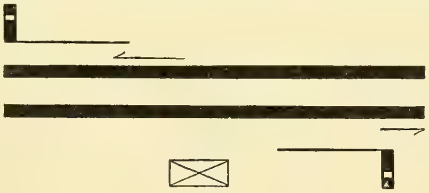


FIG. 2.

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* Adopted, Vol. 4, 1903, pp. 295-297, 299, 315-346.

signaled. In other words, no more than one track should intervene between a bracket signal post and the track for which its left upright carries the signal arm. (See Fig. 3.)

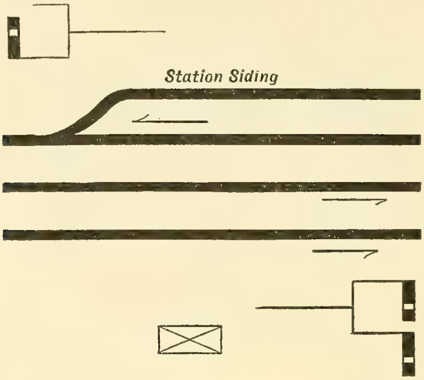

FIG. 3.

It seems proper to recognize the current practice of using flags by day and hand lamps by night. It is important, though, that a regular place for displaying these be predetermined, and there seems to be no better way than to place a regular flag socket with hook on the side of the signal station toward the direction of the approaching train, and convenient for the operator to reach from one of the windows.

The definition of "Train-Order Signal" is as follows: "A fixed signal of two indications, which in the stop position informs the engineman and conductor that they are to receive orders at the telegraph office, and in the clear position announces that there are no orders for them."

This Association recommends as good practice a fixed train-order signal, with a sweep of arm of 90 degrees from the horizontal.

*MANUAL AND CONTROLLED MANUAL BLOCK SIGNALS.

(1) The location recommended for the Manual and Controlled Manual Block Signal is on a mast alongside and to the right of the track on which are run the trains that it governs, as shown in Fig. 4; but, in the case of more than two tracks, when it is impracticable to spread them apart for this purpose, then the recommended location is on a bracket post, as in Fig. 5, or on a bridge over the tracks, as in Fig. 6.

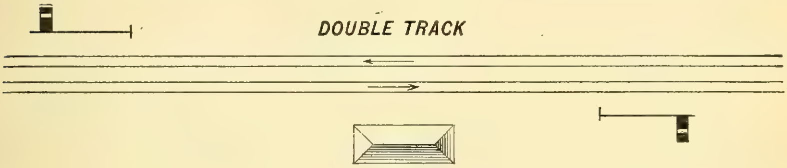

FIG. 4.

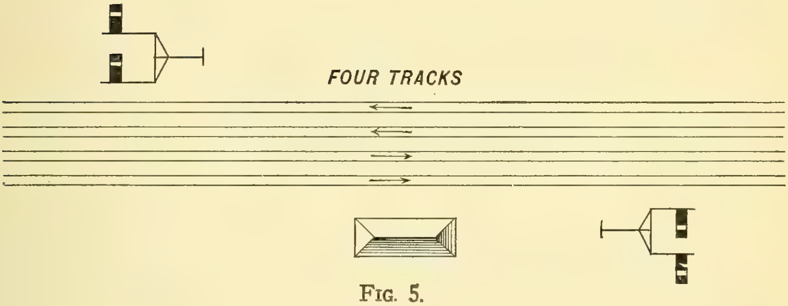

FIG. 5.

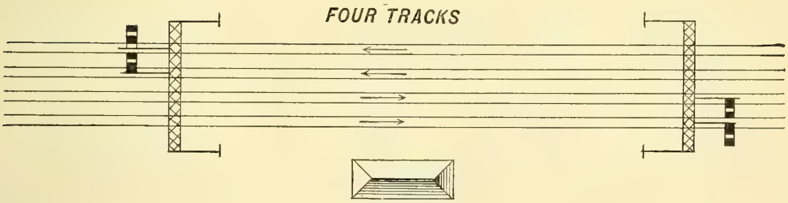

FIG. 6.

(2) It is good practice to make use of the electric slot to send the block signal to normal position, "Stop," as the train passes.

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* Adopted, Vol. 6, 1905, pp. 518, 527, 550, 551.

*LOCATION OF MANUAL BLOCK SIGNALS.

(1) The arrangement shown in Fig. 7 is good practice for use on single-track line as a train-order signal and a block signal. Distant signals may be used.

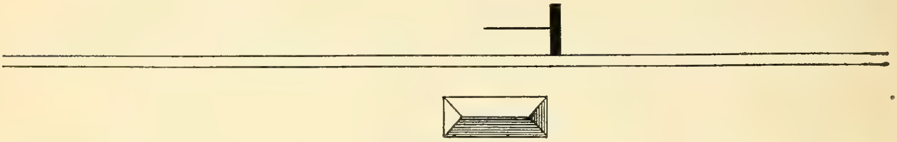

FIG. 7.

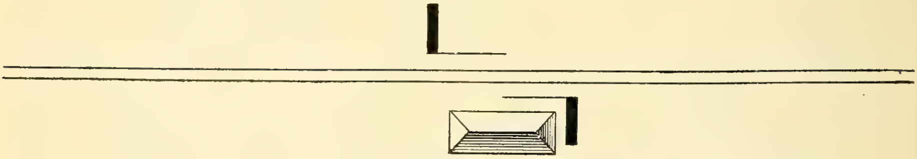

FIG. 8.

(2) The arrangement shown in Fig. 9 should be adopted when necessary to subdivide the block, and track circuit should be used in the subdivided block to control the rear signal.

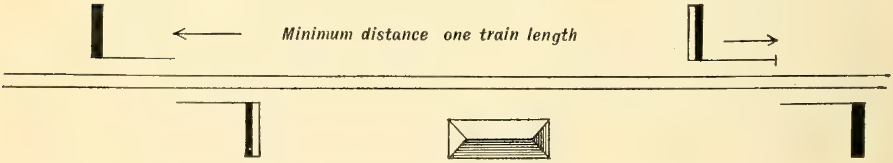

FIG. 9.

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* Adopted, Vol. 7, 1906, pp. 481, 482, 485, 539, 540.

(3) The double-track arrangement, as shown in Figs. 10 and 11, is recommended as good practice.

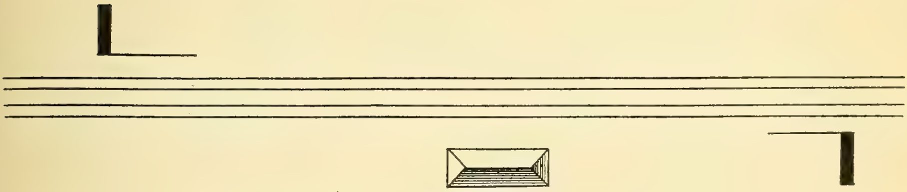

FIG. 10.

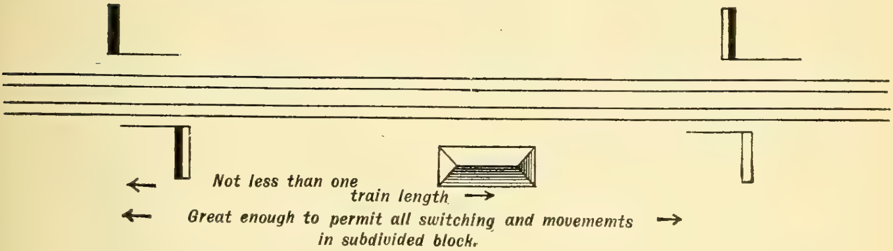
Not less than one train length
Great enough to permit all switching and movememts in subdivided block.

FIG. 11.

*ARRANGEMENT OF SIGNALS AT INTERLOCKING PLANTS.

Inasmuch as interlocking signal plants were introduced to make the passage of trains safe at speed over track layouts more or less complicated by crossovers, turnouts, and crossings, the object in arranging interlocking signals is primarily to indicate *routes* for trains, and, secondarily, as a necessary consequence, *speeds* for trains; therefore, it is recommended—

(1) That high-speed movements be governed by high signals, and low-speed movements be governed by low signals.

(2) That only two high-speed signals be displayed on one mast, the top arm to govern the unrestricted speed and the lower arm to govern all other high speeds.

(3) That all low-speed movements be governed by one-arm low signals of dwarf construction.

(4) That a distant signal be provided for each high-speed route.

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* Adopted, Vol. 6, 1905, pp. 506, 527, 547-552.

(5) That "red" be the "color" stop indication, and that the "horizontal" position of the arm be the "position" stop indication for all home signals.

(6) That a mark of distinction be made between automatic block signals, and all other home signals, whether interlocking, train-order, or manually operated block signals.

(7) That home block signals be provided at all interlocking plants used as block stations.

(8) That one distant signal only shall be provided for a high-speed route, and when "clear" it shall mean that all high-speed home signals along that route through the interlocking plant, including the home block signal, are "clear."

(9) That every movement within the limits of an interlocking plant shall be governed by an interlocked signal.

*INDICATIONS CONFERRING OR RESTRICTING RIGHTS.

The adoption of the following principles is recommended in view of the recent trend of the development of the art, and should not be understood as condemning present practice.

(1) It is recommended that the following principles of giving indications govern in formulating a signal system:

(a) That on all signals conferring or restricting rights, a red light shall be the night indication for "stop;" a yellow light shall be the night indication for "caution;" and a green light the night indication for "clear."

(b) That the day indication of semaphore signals be given in the upper right-hand quadrant.

(c) That the semaphore arm horizontal shall indicate "stop;" inclined upward 45 degrees, "caution;" and inclined upward 90 degrees, "proceed."

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* Adopted, Vol. 8, 1907, pp. 84, 97, 104.

* DIVISION OF EXPENSE OF INSTALLATION, RENEWAL AND MAINTENANCE OF JOINT INTERLOCKING PLANTS.

(1) The division of expense of the installation, renewal and maintenance of joint interlocking plants should be divided on a unit basis according to the following table:

NAME OF OPERATED UNIT.	VALUE.
One Signal Arm	1
One Pair Switch Points	1
One Derail	1
One Pair Movable Point Frogs	1
One 50-ft. Detector Bar, with or without Locks	1
One Scotch Block	1
One Torpedo Machine	1
One Power Signal	1
ELECTRIC LOCKING.	
For Each Electric Lock	1
ANNUNCIATORS AND INDICATORS.	
One Route	1

†SPECIFICATIONS FOR MINERAL MATTER RUBBER COMPOUND INSULATED SIGNAL WIRE FOR CURRENT OF 660 VOLTS OR LESS.

Conductors.

1. Conductors shall be of soft-drawn, annealed copper wire having a conductivity of not less than ninety-eight (98) per cent. of that of pure copper, Matthiessen's standard. Each wire forming a conductor shall be continuous without weld, splice or joint throughout its length, shall be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy, uniform coating of tin.

Rubber Insulation.

2. The rubber insulation shall be made exclusively from pure Upriver, fine, dry, Para rubber, of best quality, which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sulphur, properly and thoroughly vulcanized. Before being mixed with the other ingredients the rubber shall be thoroughly washed and dried.

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* Adopted, Vol. 8, 1907, pp. 72, 84, 91-95.
† Adopted, Vol. 12, Part 1, 1911.

3. The insulation shall be homogeneous in character, tough, elastic, adhering strongly to, and be placed concentrically around the wire.

Braiding.

4. The rubber insulation shall be protected with one layer of closely woven cotton braiding at least one-thirty-second ($\frac{1}{32}$) of an inch thick, saturated with a black insulating weatherproof compound that shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 200 degrees Fahrenheit.

Acceptance.

5. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the wire furnished and the acceptance of the same shall be made by the purchaser.

Tests.

6. The manufacturer shall provide at his factory apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

7. Tests shall be made from samples taken from any part of any coil and may also be made upon the finished product immediately after being delivered. If the requirements of this specification are not met the wire will be rejected and the manufacturer shall pay freight charges for return of such material.

8. At the option of the purchaser the wire, after being tested, shall not be shipped from the factory until an analysis of a sample has been made by a chemist chosen by the purchaser, and the results of such analysis, as interpreted by the purchaser, shall be sufficient ground for rejection should the wire or insulation not conform to the requirements of this specification.

Physical Test of Copper Conductors.

9. Each solid conductor shall stand an elongation of twenty-five (25) per cent. of its length in ten (10) inches before breaking, and shall be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

Conductivity Test of Copper.

10. The conductivity of the copper shall be determined by measuring the resistance of a length of the wire and comparing with Matthiessen's standard of copper resistance.

Test of Tinning.

11. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and

again washed. This operation shall be repeated three (3) times and if the sample does not become clearly blackened after the fourth immersion, the tinning shall be regarded as satisfactory.

12. The sodium sulphide solution shall contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

Tests of Braiding.

13. A six (6) inch sample of wire with carefully paraffined ends shall be submerged in fresh water of a temperature of 70 degrees Fahrenheit for a period of twenty-four (24) hours. The difference in weight of the sample before and after submersion shall not be more than ten (10) per cent. of the weight of the sample before submersion, less the weight of the copper and vulcanized rubber.

Physical Tests of Rubber Insulation.

14. A sample of the vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The sample shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths ($2\frac{7}{16}$) inches apart. The sample shall then be stretched until the marks are nine (9) inches apart before breaking.

15. The tensile strength of the rubber insulation as shown by tests made on a carefully prepared sample shall be not less than one thousand (1,000) pounds per square inch. The sample for five (5) minutes before and as near as practicable during the test shall be maintained at a temperature of 70 degrees Fahrenheit.

16. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical Tests of Rubber Insulation.

17. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent. of pure Upriver, fine, dry, Para rubber of best quality; not more than four (4) per cent. of waxy hydrocarbons consisting of refined paraffine or pure ozokerite; not more than 0.7 per cent. of free sulphur; not more than 2.5 per cent. total sulphur; freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical Tests of Rubber Insulation.

18. The circular mils cross-section, the thickness of the rubber insulation (measured at the thinnest point), the minimum insulation resistance in megohms per mile and the dielectric strength for the various sizes of wire shall conform to the following requirements:

Size B. & S. Gage.	Area in Circular Mils.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
0	105,592	⅛-in. wall	900	10,000
1	83,694	⅛-in. wall	1,100	10,000
2	66,373	⅛-in. wall	1,200	10,000
4	41,742	3-32-in. wall	1,100	9,000
6	26,250	3-32-in. wall	1,300	9,000
8	16,509	3-32-in. wall	1,600	9,000
9	13,090	5-64-in. wall	1,500	7,000
10	10,380	5-64-in. wall	1,600	7,000
12	6,530	5-64-in. wall	1,900	7,000
14	4,107	5-64-in. wall	2,100	7,000
16	2,583	1-16-in. wall	2,100	4,000
18	1,624	1-16-in. wall	2,400	4,000

19. The test for insulation resistance shall be made upon all wire after at least twelve (12) hours) submersion in water and, while still immersed, results be corrected to a water-temperature of 60 degrees Fahrenheit. Tests shall be made with the wire in coils, suitable for examination, and before the application of braid or other covering, with a well-insulated battery and galvanometer, with not less than one hundred (100) volts, and readings shall be taken after one minute's electrification. The test voltage shall be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

Coils. 20. The wire shall be furnished in coils of the length named for the following sizes of wire:

B. & S. Gage.	Length in Feet.
No. 14	2,000
No. 12	1,500
No. 10	1,500
No. 8	1,500
No. 6	1,000

21. Twenty (20) per cent. of the coils will be accepted if five hundred (500) feet long or over, or of any length where a coil, submitted for inspection and testing, has been cut to secure a sample for testing.

22. The inside diameter of a coil shall, unless otherwise specified, be not less than twenty (20) nor more than twenty-two (22) inches.

Packing for Shipment. 23. The wire shall be shipped in reels or coils, as directed by the purchaser.

24. If shipped on reels, they shall be amply strong and the wire shall be protected by lagging, to prevent injury in transportation. A tag shall be placed inside of the lagging and a stencil on the outside of each reel, giving the weight, the length of each piece of wire, the size of the wire, the name of the manufacturer and purchaser's order or inspection number plainly marked.

25. If shipped in coils, each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

26. Each coil shall have the weight, length and size of wire, the name of maker and purchaser's order or inspection number plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

*SPECIFICATIONS FOR MINERAL MATTER RUBBER COMPOUND INSULATED AERIAL BRAIDED CABLES FOR CURRENT OF 660 VOLTS OR LESS.

General.

1. The cable bought under this specification will be used for........ .... current at .... volts and shall be.................feet in length.

2. All workmanship and material shall be first-class and the best of their respective kinds, and shall be in full accord with the best modern electrical and mechanical engineering practice.

Form of Cable.

3. The cable shall consist of.. conductors insulated with rubber and stranded into cable with jute laterals to make round. The whole shall be taped and the core thus formed shall be wrapped with jute covered with a closely woven braid, as herein specified.

Conductors.

4. Conductors shall be of the following sizes and numbers:

Number of Conductors.	Approximate Nearest Size B. & S. Gage Each Conductor.	Number of Strands.	Size of Strands.	Actual C. M. of Conductor.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

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* Adopted, Vol. 12, Part 2, 1911.

5. Conductors shall be of soft-drawn, annealed copper wire, having a conductivity of not less than ninety-eight (98) per cent. of that of pure copper, Matthiessen's standard. Each wire forming a conductor shall be continuous without weld, splice or joint throughout its length, shall be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy, uniform coating of tin.

Rubber Insulation.

6. The rubber insulation shall be made exclusively from pure Upriver, fine, dry, Para rubber of best quality, which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sulphur, properly and thoroughly vulcanized. Before being mixed with the other ingredients, the rubber shall be thoroughly washed and dried.

7. The insulation shall be homogeneous in character, tough, elastic, adhering strongly to, and be placed concentrically around the wire.

Taping, Filling and Braiding.

8. The core of the cable shall be made cylindrical in form and properly laid up, with one wire in each layer taped for a tracer. Cables of more than three (3) and less than seven (7) conductors shall be made up with a jute or sisal center. Each layer of core shall have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. All interstices between insulated conductors shall be thoroughly filled with dry jute to make round, and covered with a layer of rubber insulating tape overlapping for one-third (⅓) its width. The tape shall be of closely woven cotton, filled with rubber insulating compound and laid to make a smooth surface.

9. A bedding of jute, not less than one-sixteenth ($\frac{1}{16}$) inch thick and saturated with tar, shall be wrapped over the taped core. A layer of tape, overlapping one-third (⅓) its width, shall be laid on over the jute in reverse order to the winding of the jute, and over this shall be placed one (1) layer of closely woven cotton braiding at least one-thirty-second ($\frac{1}{32}$) inch thick, saturated with a black, insulating weather-proof compound that shall be neither injuriously affected by nor have an injurious effect on the braid at a temperature of 200 degrees Fahrenheit.

Acceptance.

10. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the cable furnished and the acceptance of the same shall be made by the purchaser.

Tests.

11. The manufacturer shall provide, at his factory, apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture

and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

12. Tests shall be made from samples taken from any part of any coil of wire and shall also be made upon the finished product before, and, if desired, immediately after being delivered. If the requirements of this specification are not met, the cable will be rejected.

13. At the option of the purchaser, the wire, after being tested, shall not be made into a cable until an analysis of a sample has been made by a chemist chosen by the purchaser, and the results of such analysis, as interpreted by the purchaser, shall be sufficient ground for rejection, should the wire or insulation not conform to the requirements of this specification.

Physical Test of Copper Conductors.

14. Each solid conductor shall stand an elongation of twenty-five (25) per cent. of its length in ten (10) inches before breaking. It shall be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

15. The conductivity of the copper shall be determined by measuring the resistance of a length of wire and comparing with Matthiessen's standard of copper resistance.

Test of Tinning.

16. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity of 1.088 for one minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times and if the sample does not become clearly blackened after the fourth immersion the tinning shall be regarded as satisfactory.

17. The sodium sulphide solution shall contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean, untinned copper wire in five (5) seconds.

Physical Tests of Rubber Insulation.

18. A sample of vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The samples shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths ($2\frac{7}{16}$) inches apart. Samples shall then be stretched until the marks are nine (9) inches apart before breaking.

19. The tensile strength of the rubber insulation as shown by tests made on a carefully prepared sample shall be not less than one thousand

(1,000) pounds per square inch. The sample, for five (5) minutes before and, as near as practicable, during the test, shall be maintained at a temperature of 70 degrees Fahrenheit.

20. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical Tests of Rubber Insulation.

21. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent. of pure Upriver, fine, dry, Para rubber, of best quality; not more than four (4) per cent. of solid waxy hydrocarbons consisting of refined paraffine or pure ozokerite; not more than 0.7 per cent. of free sulphur; not more than 2.5 per cent. total sulphur, freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical Tests of Rubber Insulation.

22. The thickness of the rubber insulation around each conductor (measured at the thinnest point), the minimum insulation resistance in megohms per mile when corrected to the standard temperature of 60 degrees Fahrenheit, and the dielectric strength shall conform to the following requirements:

B.& S. Gage.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
4	3-32 inch	1,100	9,000
6	5-64 inch	1,300	7,000
8	5-64 inch	1,600	7,000
9	5-64 inch	1,500	7,000
10	1-16 inch	1,400	4,000
12	1-16 inch	1,600	4,000
14	1-16 inch	1,900	4,000
16	3-64 inch	1,900	2,000

23. The test for insulation resistance shall be made upon all wire after at least twelve (12) hours' submersion in water, and, while still immersed, results be corrected to a water temperature of 60 degrees Fahrenheit. Tests shall be made with the wire in coils, suitable for examination and before the application of tape or other covering, with a well-insulated battery and galvanometer, with not less than one hundred (100) volts, and readings shall be taken after one (1) minute's electrification. The test voltage shall be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

24. The cable, when made up after assembling and braiding, shall have the test voltage required for separate conductors, applied between conductors for five (5) minutes to each conductor.

25. The insulation resistance of each conductor shall be measured after test voltage has been applied to the completed cable, and the resistance found shall be not less than that specified for separate conductors.

Inspection. 26. The manufacturer shall notify the purchaser when the manufacture of the wire and cable is to begin, in order that inspection may be arranged for.

Reels. 27. Each cable shall be placed on a separate reel, holding the full length of cable. Both ends of cable shall be accessible for testing, but be covered and protected from injury. The flanges of the reel shall be large enough to protect the cable in handling and rolling. The reels will become the property of the purchaser, but shall be taken back by the manufacturer upon the request of the purchaser.

Marking. 28. Each reel shall have the weight, length, number of conductors in cable, the name of maker and purchaser's order or inspection number plainly and indelibly marked on a strong tag securely fastened to the cable and also stenciled on the outside of the reel.

Notification. 29. The completed cable is not to be shipped from place of manufacture until permission in writing has been received from the purchaser. Should the cable, on arrival at destination, be found defective and not up to the specification requirements, it will be returned to the manufacturer, who shall pay all freight charges.

* SPECIFICATIONS FOR MINERAL MATTER RUBBER COMPOUND, INSULATED, LEAD-COVERED, ARMORED SUBMARINE CABLE FOR 660 OR LOWER VOLTAGE SERVICE.

General. 1. The cable bought under this specification will be used under water for.................................. current at...................... volts, and shall be......................feet in length.

2. All workmanship and material shall be first-class and the best of their respective kinds, and shall be in full accord with the best modern electrical and mechanical engineering practice.

Form of Cable. 3. The cable shall consist of..................conductors insulated with rubber and stranded into cable with jute laterals to make round, the whole to be taped, and the core thus formed shall have lead sheath with jute covering over lead, with armor and a covering of jute over the armor as herein specified.

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* Adopted, Vol. 12, Part 1, 1911.

Conductors.

4. Conductors shall be of the following sizes and numbers:

Number of Conductors.	Approximate Nearest Size B. & S. Gage Each Conductor.	Number of Strands.	Size of Strands.	Actual C. M. of Conductor.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

5. Conductors shall be of soft-drawn, annealed copper wire, having a conductivity of not less than ninety-eight (98) per cent. of that of pure copper, Matthiessen's standard. Each wire forming a conductor shall be continuous without weld, splice or joint throughout its length, shall be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy uniform coating of tin.

Rubber Insulation.

6. The rubber insulation shall be made exclusively from pure Upriver, fine, dry, Para rubber, of best quality, which has not previously been used in a rubber compound, solid waxy hydrocarbon, suitable mineral matter and sulphur properly and thoroughly vulcanized. Before being mixed with the other ingredients the rubber shall be thoroughly washed and dried.

7. The insulation shall be homogeneous in character, tough, elastic, adhering strongly to, and be placed concentrically around the wire.

Taping and Filling.

8. The core of the cable shall be made cylindrical in form and properly laid up with one wire in each layer taped for a tracer. Cables of more than three (3) and less than seven (7) conductors shall be made up with a jute or sisal center. Each layer of core shall have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. All interstices between insulated conductors shall be thoroughly filled with dry jute to make round, and covered with a layer of rubber insulating type overlapping for one-third (⅓) its width.

9. The tape shall be of closely woven cotton filled with rubber insulating compound and laid to make a smooth surface. The jute is to be well twisted and is to be applied spirally.

Sheath.

10. A sheath one-eighth (⅛) of an inch in thickness, consisting of an alloy of lead and tin, containing not less than ninety-eight (98) per cent. pure lead and from one (1) to two (2) per cent. tin, shall be applied over the assembled and taped conductors.

Armoring and Braiding.

11. The sheath shall be protected by a layer of asphalt or tarred jute, well twisted and applied spirally and having a thickness of three-thirty-

seconds ($\frac{3}{32}$) of an inch. Over the jute covering shall be placed a covering consisting of No. 4 B. & S. gage galvanized mild steel wires applied spirally and laid to fit closely one wire to the next.

12. Over the armoring a layer of closely woven jute braiding shall be placed at least one-sixteenth ($\frac{1}{16}$) inch thick, saturated with a black insulating weatherproof compound that shall be neither injuriously affected by nor have an injurious effect upon the braid at 200 degrees Fahrenheit.

Acceptance.

13. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the cable furnished and the acceptance of the same shall be made by the purchaser.

Tests.

14. The manufacturer shall provide at his factory apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

15. Tests shall be made from samples taken from any part of any coil of wire and shall also be made upon the finished product before, and, if desired, immediately after being delivered. If the requirements of this specification are not met the cable will be rejected.

16. At the option of the purchaser, the wire after being tested shall not be made into a cable until an analysis of a sample has been made by a chemist chosen by the purchaser, and the result of such analysis, as interpreted by the purchaser, shall be sufficient ground for rejection, should the wire or insulation not conform to the requirements of this specification.

Physical Test of Copper Conductors.

17. Each solid conductor shall stand an elongation of twenty-five (25) per cent. of its length in ten (10) inches before breaking. It shall be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

Conductivity Test of Copper.

18. The conductivity of the copper shall be determined by measuring the resistance of a length of wire and comparing with Matthiessen's standard of copper resistance.

Test of Tinning.

19. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times, and if the

sample does not become clearly blackened after the fourth immersion the tinning shall be regarded as satisfactory.

20. The sodium sulphide solution shall contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

Physical Tests of Rubber Insulation.

21. A sample of vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The samples shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths (2$\frac{7}{16}$) inches apart. Samples shall then be stretched until the marks are nine (9) inches apart before breaking.

22. The tensile strength of the rubber insulation, as shown by tests made on a carefully prepared sample, shall be not less than one thousand (1,000) lbs. per square inch. The sample, for five (5) minutes before and, as near as practicable, during the test, shall be maintained at a temperature of 70 degrees Fahrenheit.

23. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical Tests of Rubber Insulation.

24. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent. of pure Upriver, fine, dry, Para rubber, of best quality; not more than four (4) per cent. of solid waxy hydrocarbons, consisting of refined paraffine or pure ozokerite; not more than 0.7 per cent. of free sulphur; not more than 2.5 per cent. total sulphur, freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical Tests of Rubber Insulation.

25. The thickness of the rubber insulation around each conductor (measured at the thinnest point), the minimum insulation resistance in megohms per mile when corrected to the standard temperature of 60 degrees Fahrenheit, and the dielectric strength shall conform to the following requirements:

B.&S. Gage.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
0	⅛ inch	900	10,000
1	⅛ inch	1,100	10,000
2	⅛ inch	1,200	10,000
4	3-32 inch	1,100	9,000
6	3-32 inch	1,300	9,000
8	3-32 inch	1,600	9,000
9	5-64 inch	1,500	7,000
10	5-64 inch	1,600	7,000
12	5-64 inch	1,900	7,000
14	5-64 inch	2,100	7,000
16	1-16 inch	2,100	4,000

26. The test for insulation resistance shall be made upon all wire after at least twelve (12) hours' submersion in water and while still immersed results be corrected to a water temperature of 60 degrees Fahrenheit. Tests shall be made with the wire in coils, suitable for examination and before the application of tape or other covering with a well-insulated battery and galvanometer, with not less than one hundred (100) volts and readings shall be taken after one minute's electrification. The test voltage shall be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

27. The cable when made up after assembling with lead covering and armoring shall have the test voltage applied for five (5) minutes to each conductor as follows:

28. Between conductors apply the full voltage tests as required for separate wires.

29. Between each conductor and lead sheath apply a test voltage of but sixty (60) per cent. of that required for separate wire.

30. The insulation resistance of each conductor shall be measured after test voltage has been applied to the completed cable and the resistance found shall be not less than that specified for separate conductors.

31. The manufacturer shall notify the purchaser when the manufacture of the wire and cable is to begin in order that inspection may be arranged for. Inspection.

32. Each cable shall be placed on a separate reel holding the full length of cable. Both ends of cable shall be accessible for testing but be covered and protected from injury. The flanges of the reel shall be large enough to protect the cable in handling and rolling. The reels will become the property of the purchaser, but shall be taken back by the manufacturer upon the request of the purchaser. Reels.

33. Each reel shall have the weight, length, number of conductors in cable, the name of maker and purchaser's order or inspection number plainly and indelibly marked on a strong tag securely fastened to the cable and also stenciled on the outside of the reel. Marking.

34. The completed cable is not to be shipped from place of manufacture until permission in writing has been received from the purchaser. Should the cable on arrival at destination be found defective and not up to the specification requirements, it will be returned to the manufacturer, who shall pay all freight charges. Notification.

* SPECIFICATIONS FOR DOUBLE-BRAIDED, WEATHERPROOF, HARD-DRAWN, COPPER LINE WIRE.

General Description. 1. The intention of this specification is to provide for the furnishing of hard-drawn copper line wire, which is covered with a double thickness of weatherproof braiding.

Conductor. 2. The wire shall be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil shall contain no weld, joint or splice.

Properties. 3. The mechanical and electrical properties of the finished wire shall be in accord with the following requirements:

B. & S. Gage.	Diameter in Mils.	Breaking Strength, Pounds.	Per Cent. Elongation in 10 Inches.	Conductivity Per Cent of Pure Copper.
6	162	1,210	1.12	97
7	144	970	1.08	97
8	128	779	1.06	97
9	114	620	1.04	97
10	102	502	1.02	97
12	81	319	1.00	97

Covering. 4. The conductor shall be covered with two (2) closely woven braids of cotton, each of which shall not be less than one-thirty-second ($\frac{1}{32}$) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

5. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit, or such as will soften the wire more than is allowable with the elastic limit required. The wire shall remain in the compound and shall be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

6. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of 125 degrees Fahrenheit, and shall not crack when the finished wire is subjected to a temperature of 10 degrees below zero Fahrenheit.

7. The qualities of the compound and the method of application shall be such as not to injure the braided covering or the wire.

8. The melting and freezing tests of the compound shall be made as follows:

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* Adopted, Vol. 12, Part 1, 1911.

Short pieces of wire shall be placed on a piece of clean, white, glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed in sufficient amount to form a ridge perceptible to the fingers, or in case the compound is absorbed by the paper, as indicated by a greasy or oily spot.

9. The finished wire shall be immersed in a freezing mixture, which shall show a temperature of 10 degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in its surface, the wire shall be rejected.

Inspection and Tests.

10. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

11. The manufacturer shall provide at the mill all apparatus and labor for making the required tests under the supervision of the purchaser.

12. Tests shall be made at the mill or on samples submitted by the manufacturer and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

13. If, upon arrival at destination the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for Shipment.

14. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive	One-fourth mile
6 to 8, inclusive	One-third mile
9 to 12, inclusive	One-half mile

15. The diameter of the eye of the coil shall be not less than twenty (20) inches nor more than twenty-two (22) inches.

16. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

17. Each coil shall have the weight, length and size of wire, the name of maker, the purchaser's order and inspection number and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

* SPECIFICATIONS FOR DOUBLE-BRAIDED, WEATHERPROOF, GALVANIZED B. B. LINE WIRE.

General Description.

1. The intention of this specification is to provide for the furnishing of galvanized B. B. line wire which is covered with a double thickness of weatherproof braiding.

Conductor.

2. The wire shall be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil shall contain no weld, joint or splice.

3. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness and so applied that it adheres firmly to the iron and presents a smooth surface.

Properties.

4. The mechanical and electrical properties of the finished wire shall be in accord with the following requirements:

B. W. Gage.	Diameter in Mils.	Breaking Strength, Pounds.	Per Cent. Elongation in 10 Inches	Resistance Ohms per Mile at 68 Degrees F.
6	203	1,652	15	9.49
8	165	1,092	15	14.36
10	134	722	12	21.71
12	109	476	12	32.94

Test of Galvanizing.

5. A sufficient number of samples shall be taken from the wire submitted for inspection and shall be tested, these pieces being not less than eight (8) inches long, and not more than seven (7) pieces of wire shall be immersed in the specified quantity of solution.

6. The samples shall be cleaned before being tested, first with carbona, benzine or turpentine and cotton waste, and then thoroughly rinsed in clear water and wiped dry with clean cotton waste. The samples shall be cleaned and dried before being immersed in the solution. The samples, when placed in the solution, shall be well separated to permit the solution to act uniformly on all immersed portions of the samples.

7. The samples shall be tested in a neutral solution of commercial copper sulphate having a specific gravity of 1.186 at a temperature of 65 degrees Fahrenheit. The solution shall be neutralized by the addition of excess of chemically pure cupric oxide (CuO) which will collect in the bottom of the containing vessel. The solution shall be filtered before being used. Not less than four (4) ounces of fresh solution shall be used for each test of seven (7) wires. The solution shall be maintained at a temperature between 62 and 68 degrees Fahrenheit during the test. The samples shall be immersed in the solution to a depth of four (4) inches.

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* Adopted, Vol. 12, Part 1, 1911.

8. The samples shall be immersed in the solution for one (1) minute, shall then be washed in clean water having a temperature of between 62 and 68 degrees Fahrenheit and be wiped dry with clean cotton waste. This operation shall be performed four (4) times.

9. If there is a bright metallic copper deposit on the samples after the fourth immersion, the wire represented by the samples shall be rejected, but copper deposited on zinc or within one (1) inch of the end of the sample shall not be considered as cause for rejection.

10. In case of a failure of one (1) wire in the group of seven (7) being tested together, or if there is reasonable doubt as to the copper deposit, two (2) check tests shall be made of samples from the same coil, but unless the two (2) check tests are satisfactory the wire shall be rejected.

Covering.

11. The conductor shall be covered with two (2) closely woven braids of cotton, each of which shall not be less than one-thirty-second ($\frac{1}{32}$) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

12. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit or such as will soften the wire more than is allowable with the elongation required. The wire shall remain in the compound long enough to drive out all moisture in the covering and shall be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

13. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of 125 degrees Fahrenheit and shall not crack when the finished wire is subjected to a temperature of 10 degrees below zero Fahrenheit.

14. The qualities of the compound used and the method of application shall be such as not to injure the braided covering of the wire.

15. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean, white, glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed in sufficient amount to form a ridge perceptible to the fingers or in case the compound is absorbed by the paper, as indicated by a greasy or oily spot.

16. The finished wire shall be immersed in a freezing mixture which shall show a temperature of 10 degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in its surface, the wire shall be rejected.

Inspection and Tests.

17. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

18. The manufacturer shall provide at the mill all apparatus and labor for making the required tests, under the supervision of the purchaser.

19. Tests shall be made at the mill or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

20. If, upon arrival at destination, the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for Shipment.

21. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive	One-fourth mile
6 to 8, inclusive	One-third mile
9 to 12, inclusive	One-half mile

22. The diameter of the eye of the coil shall be not less than twenty (20) inches nor more than twenty-two (22) inches.

23. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

24. Each coil shall have the weight, length and size of wire, the name of the maker, the purchaser's order and inspection number and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

* SPECIFICATIONS FOR DOUBLE-BRAIDED, WEATHERPROOF, HARD-DRAWN, COPPER-CLAD, STEEL LINE WIRE.

General Description.

1. The intention of this specification is to provide for the furnishing of copper-clad, steel line wire which is covered with a double thickness of weatherproof braiding.

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* Adopted, Vol. 12, Part 1, 1911.

Conductor.

2. The wire shall be composed of a steel core with a copper coat permanently welded thereto. The wire shall be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil shall contain no weld, joint or splice.

Properties.

3. The mechanical and electrical properties of the finished wire shall be in accord with the following requirements:

B. & S. Gage.	Diameter in Mils.	Breaking Strength, Pounds.	Conductivity Per Cent. of Pure Copper at 60 Deg. F.
6	162	1,700	35
7	144	1,450	35
8	128	1,150	35
9	114	950	35
10	102	760	35
12	81	490	35

4. The wire, when broken by twisting, repeated bending, or when heated to a dull red and quenched in water at 32 degrees Fahrenheit, shall show no separation of the copper from the steel.

5. Should the breaking weight of the coil be less than that specified, tests of two (2) additional samples shall be made from the same coil and the average of the three (3) tests shall determine the acceptance or rejection of the coil.

6. Should the conductivity of a sample of a coil be lower than that specified, pieces may be cut from each end until samples are obtained having the required conductivity.

Covering.

7. The conductor shall be covered with two (2) closely woven braids of cotton, each of which shall not be less than one-thirty-second ($\frac{1}{32}$) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

8. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit, or such as will soften the wire more than is allowable with the elongation required. The wire shall remain in the compound long enough to drive out all moisture in the covering, and shall be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

9. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of 125 degrees Fahrenheit and shall not crack when the finished wire is subjected to a temperature of 10 degrees below zero Fahrenheit.

10. The qualities of the compound used and the method of application shall be such as not to injure the braided covering of the wire.

11. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean, white, glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed, in sufficient amount to form a ridge perceptible to the fingers or in case the compound is absorbed by the paper, as indicated by a greasy or oily spot.

12. The finished wire shall be immersed in a freezing mixture which shall show a temperature of 10 degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in the surface, the wire shall be rejected.

Inspection and Tests.

13. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

14. The manufacturer shall provide at the mill all apparatus and labor for making the required tests, under the supervision of the purchaser.

15. Tests shall be made at the mill or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

16. If, upon arrival at destination, the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for Shipment.

17. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive	One-fourth mile
6 to 8, inclusive	One-third mile
9 to 12, inclusive	One-half mile

18. The diameter of the eye of the coil shall be not less than twenty (20) inches nor more than twenty-two (22) inches.

19. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

20. Each coil shall have the weight, length and size of wire, name of

maker, the purchaser's order and inspection number, and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

*SPECIFICATIONS FOR GALVANIZED E. B. B. IRON BOND WIRES.

General Description.

1. The intention of this specification is to provide for the furnishing of No. 8 B. W. G. galvanized E. B. B. iron wires for bonding rail joints of steam railways where electric track circuits are to be used.

Conductor.

2. The wire shall be cylindrical in form, free from scales, flaws. inequalities, splits and all imperfections. The wires shall be cut and straightened to the length specified on order. The ends shall be sheared cut and free from burrs.

3. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness and so applied that it adheres firmly to the iron and presents a smooth surface.

Properties.

4. The mechanical and electrical properties of the finished wire shall be in accord with the following requirements:

B. W. G.	Diameter in Mils.	Breaking Resistance, Pounds.	Per Cent. Elongation in 10 Inches.	Resistance Ohms Per Mile at 68 Deg. F.
8	165	975	15	12.05

The wire shall not vary more than three (3) mils from the normal diameter.

Test of Galvanizing.

5. A sufficient number of samples shall be taken from the wire submitted for inspection and shall be tested, these pieces being not less than eight (8) inches long and not more than seven (7) pieces of wire shall be immersed in the specified quantity of solution.

6. The samples shall be cleaned before being tested, first with carbona, benzine or turpentine and cotton waste, and then thoroughly rinsed in clean water and wiped dry with clean cotton waste. The samples shall be cleaned and dried before being immersed in the solution. The samples, when placed in the solution, shall be well separated to permit the solution to act uniformly on all immersed portions of the samples.

7. The samples shall be tested in a neutral solution of commercial copper sulphate having a specific gravity of 1.186 at a temperature of 65

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* Adopted, Vol. 12, Part 2, 1911.

degrees Fahrenheit. The solution shall be neutralized by the addition of excess of chemically pure cupric oxide (CuO) which will collect in the bottom of the containing vessel. The solution shall be filtered before being used. Not less than four (4) ounces of fresh solution shall be used for each test of seven (7) wires. The solution shall be maintained at a temperature between 62 and 68 degrees Fahrenheit during the test. The samples shall be immersed in the solution to a depth of four (4) inches.

8. The samples shall be immersed in the solution for one minute, shall then be washed in clean water having a temperature of between 62 and 68 degrees Fahrenheit and be wiped dry with clean cotton waste. This operation shall be performed four (4) times.

9. If there is a bright metallic copper deposit on the samples after the fourth immersion, the wire represented by the samples shall be rejected, but copper deposited on zinc or within one (1) inch of the end of the sample shall not be considered as cause for rejection.

10. In case of a failure of one (1) wire in the group of seven (7) wires being tested together, or if there is reasonable doubt as to the copper deposit, two (2) check tests shall be made of samples from the same bundle, but unless the two (2) check tests are satisfactory, the wire shall be rejected.

Inspection and Tests.

11. The purchaser is to have the right to make such inspection and tests as he may desire of the wire at any stage of the manufacture.

12. The manufacturer shall provide, at the mill, all apparatus and labor for making the required tests, under the supervision of the purchaser.

13. Tests shall be made at the mill on the wire before it is cut into lengths, or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination.

14. If, upon arrival at destination, the wires do not meet the requirements of this specification, they will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for Shipment.

15. The wire shall be put up in bundles of one hundred (100) or three hundred (300), as ordered, well burlapped at ends and securely fastened in not less than three (3) places.

Tagging.

16. A tag shall be securely fastened to each bundle, having plainly and indelibly marked thereon the number of and length of the wires, the purchaser's order and inspection number and the proper shipping address.

*STRANDED CONDUCTORS.

Approximate Size, B. & S. Gage.	Number of Strands.	Actual Circular Mils.
2000000	127	2000250
1500000	91	1502592
1000000	91	1003275
900000	91	900900
800000	91	804076
700000	61	698389
600000	61	597861
500000	37	506493
400000	37	400192
350000	37	351722
300000	37	299700
250000	37	248788
0000	19	211470
000	19	167884
00	19	132468
0	19	105450
1	19	84018
2	19	66139
3	7	52274
4	7	41503
5	7	33327
6	7	26047
8	7	16464
9	7	12943
10	7	10374
12	7	6300
14	7	4375
16	7	2527
18-7 No. 26	7	1778
20-7 No. 28	7	1113
21-7 No. 29	7	889
22-7 No. 30	7	700

FLEXIBLE CONDUCTORS.

Approximate Size, B. & S. Gage.	Number of Strands.	Actual Circular Mils.
0000	37	210900
000	37	168572
00	37	133200
0	37	105894
1	37	83472
2	37	66822
3	19	52364
4	19	41971
5	19	33516
6	19	26011
8	19	17011
9	19	12844
10	19	10051
12	19	6498
14	19	3990
16	19	2508
18-7 No. 26	19	1501

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* Adopted, Vol. 12, Part 1, 1911.

Size of Sheet—8½x13⅞ inches. Form M. W. 1001.

A. B. & C. R. R. Co.

*WIRE INSPECTION REPORT NO........

........................191......

Manufacturer ....
Location of factory..Reqn. No...........
Whose order ....Order No...........

GENERAL DESCRIPTION.

Test of ....
To be located at..............................Working Voltage..................
Single conductor: Length......ft. Size......B. & S. Wall......in. Reels......

CABLE
Length.......ft. Armor.......B. & S. Lead sheath.......in. Reels......

Composition.

No. of Cond.	Size, B. & S.	No. of Strands.	Size of Strands.	Wall.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

SPECIFICATION REQUIREMENTS.

Voltage....volts A. C. for....min. Insulation resistance....megs. per mile at 60° F.
Tensile strength of insulation.....lbs. per sq. in. Tensile strength of copper.....lbs. per sq. in.
Permanent set of insulation, 20%. Conductivity, 98% at 60° F.
Elongation of insulation, 350%. Pure Para rubber, 30%.

PHYSICAL TESTS.

CONDUCTOR.	INSULATION.
Elongation............% in......inches	Elongation............% in......inches
Torsion............twists in......inches	Permanent set..........% in......inches
Tensile strength..........lbs. per sq. in.	Tensile strength..........lbs. per sq. in.

CHEMICAL TESTS.

Conductor Tinning Test: Immersed...........times before blackening.
Insulation—Pure Para rubber.....%. Sulphur.....%. Dry mineral matter.....%.

BRAIDING TESTS.

Gain..........% of weight of braid after..........hours immersion at..........° F.

ELECTRICAL TESTS.

1. **Voltage Test:** Unbraided wire tested..........Volts A. C. for........Min.
Remarks..
2. **Conductivity Test:** ....% of Matthiessen's Standard at 60° F.
3. **Insulation Resistance Test:** Temperature........° F. Constant........Megs.
Time immersed......Hrs. Voltage of cells volts...

Coil Nos.	Length.	Defls.	Meg. Mile.	Coil Nos.	Length.	Defls.	Meg. Mile.
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....

................................Inspector.

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* Adopted, Vol. 12, Part 1, 1911.

COMMITTEE XI.

RECORDS AND ACCOUNTS.

*DEFINITIONS.

RECORDS.—Information or data in graphical, tabular or statement form relating to physical characteristics, conditions, cost and such other information as may seem desirable for record.

REPORTS.—The medium through which information is transmitted from one to another official and from which records and accounts are prepared or compiled in the filing office.

ACCOUNTS.—Statements required to enable payments to be made for labor performed and material furnished, or to establish the detail, total and comparative cost of work and various classes of expenses.

LEDGER ACCOUNTS FOR INDIVIDUAL PIECES OF WORK.—Statements kept in ledger form in order to establish the detail, total and comparative cost of any particular work or class of expenses.

CONVENTIONAL SIGNS.—Symbols, such as a mark, character, abbreviation or letter selected or sanctioned by general agreement and used to indicate upon a map or plan certain forms, conditions and objects both natural and structural.

PROGRESS PROFILE.—A graphical record of the progress of work prepared at stated periods.

TRACK CHART.—A diagram showing the physical characteristics of track and roadbed.

RIGHT-OF-WAY MAP.—A plat representing the actual location and dimensions of the property, rights or franchises that are owned or controlled by a railway company.

TRACK MAP.—A map used primarily for showing existing physical conditions, including tracks, bridges, buildings, water service and mains, leases, station facilities and all of the physical and operating features.

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* Adopted, Vol. 7, 1906, pp. 279, 318; Vol. 9, 1908, pp. 663, 664, 667, 668, 677, 686.

*FILING DUPLICATE RECORDS IN SEPARATE LOCALITIES FOR PROTECTION IN CASE OF FIRE.

Duplicate copies of record books and maps, particularly right-of-way maps, should be kept in quite widely separated localities, so that the trouble and expense of reproducing the same will be greatly reduced in case of fire or accident.

†BRIDGE DEPARTMENT FORMS.

STANDARD FORMS.

(1) The following standard forms are considered essential and recommended as the special forms for a regular working Maintenance of Way Bridge Department:

Monthly Bridge Material Report	M. W. 1100
Foreman's Diary, Bridge Department	M. W. 1101
Bridge Department Tool Report	M. W. 701
Structure Report	M. W. 1004
Current Bridge Inspection Report	M. W. 702
Summary Current Bridge Inspection Report	M. W. 703
General Bridge Inspection Report	M. W. 704

(2) In Bridge Inspection there should be a clear distinction made between Current Inspection and General Inspection. The purpose of the Current Inspection is to keep the structure in safe condition, to promptly discover any defects and to report the same promptly, so that repairs can be made before the safety of the structure is affected. It is important that a simple record should be made while at the bridge and that the superior officer be kept advised of all such inspections promptly, whether made by a Bridge Mechanic, Gang Foreman, Division Bridge Inspector, Master Carpenter, or others.

The purpose of the General Inspection, frequently called the annual inspection, although in many cases conducted semi-annually or even quarterly, is not only to check the maintenance work of the division organization, but to make a more careful investigation of important

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* Adopted, Vol. 5, 1904, pp. 286, 371, 377 (see Vol. 2, 1901, p. 322); Vol. 6, 1905, pp. 658, 668.

†Adopted, Vol. 5, 1904, pp. 237, 372-375; Vol. 6, 1905, pp. 656, 657, 668; Vol. 11, 1910, pp. 1100, 1103, 1141.

bridges and structures on the entire road, and, further, to ascertain and determine what extensive repair work or renewal work should be done in the following working season.

(3) The general forms of the railway should be used in all departments, including the Bridge Department, as far as applicable; for example, one form for reporting time should be used in all departments, the form being designed accordingly.

(4) Bridge records, when properly kept up to date in an accurate manner, will prove of the highest value to railways and are essential for any system of complete and proper bridge records. However, forms in connection with bridge records are not specially necessary for a Bridge Department, but are necessary generally for the compilation of records for several departments, and hence these forms are not recommended as standard special Bridge Department forms.

(5) Numerous minor special forms are used on all railways for reporting information necessary to keep bridge records up to date, but such forms should be regulated by each individual railway, according to its peculiar requirements, and hence no standard forms for this purpose are recommended.

Size 8x13 inches. Form M. W. 1100.

A. B. & C. R. R. Co.

____________________DIVISION

MONTHLY BRIDGE MATERIAL REPORT

____________________ Month of____________________19___

(Gang or District.)

KIND OF MATERIAL	UNIT	ON HAND FIRST OF MONTH	RECEIVED	DISPOSED OF		ON HAND END OF MONTH	REMARKS
				USED	SHIPPED AWAY		
←2."0→	←0."5→	←0."7→	←0."7→	←0."7→	←0.'7→	←0."7→	←2."0→
THREE SPACES PER INCH							

The above statement is correct:

....
Foreman of Bridges.

Correct: .... Master Carpenter

Form M. W. 1100.

A. B. & C. R. R. Co.

....
(Gang or Dist.)

....DIVISION

MONTHLY
BRIDGE MATERIAL REPORT

For..........Ending..........19..

Foremen are required to make the above report..........and forward same to Master Carpenter..........., who will, after examining, approve it and forward to Division Engineer.

To be filed in the office of Division Engineer.

SPECIFICATIONS FOR FORM M. W. 1100.

Form as here shown. Size 8x13 inches. Vertical lines, red; horizontal lines, blue.

SPECIFICATIONS FOR FORM M. W. 1101.

Foreman's Diary—Bridge Department.

To be issued in book form. Size of pages, 5¼x8 inches. Size of book, 5½x8½ inches.

A. B. & C. R. R. Co.

____
(Gang or District)

______________________DIVISION

FOREMAN'S DIARY

BRIDGE DEPARTMENT

Month of______________________19__

____
Foreman of Bridges.

I certify that I have examined the within account of Material used on each job, and find it correct.

____
Master Carpenter.

Size of page 5¼x8 inches. Form M. W. 1101

INSTRUCTIONS TO FOREMEN.

This Diary to be kept by Foremen of Bridges and sent to Master Carpenter and by latter sent to Division Engineer.

In entering in this Diary material used on different jobs you will be governed by the following rules:

Enter the location, name and description of job by giving No. of each bridge or culvert in the column provided for that purpose.

Enter No. or size and name of articles used on each job in proper column, stating quantity, old or new; in case of lumber, give kind (oak, white or yellow pine, etc.).

Always show whether work is complete or not complete in column provided for that purpose. Job should not be noted as "Complete" before all labor as well as material is expended. If a job is complete with labor and without material, Diary should show the job and opposite it notation should be made "No material."

Material must be reported by the correct name.

Columns headed "Charge," "Price" and "Amount" should not be used by mechanics, but should be filled out in Division Engineer's office.

Show where material was taken from—Stock or Storehouse. If from Storehouse, give name of same.

This book should be sent forward promptly at the end of each month.

Enter weight or measure of articles used on the job in columns headed "Quantity," as follows:

....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....
....	....

Form M. W. 1101

ACCOUNT OF MATERIAL

During the month of______________________________19___

Date.	LOCATION, NAME AND DESCRIPTION OF WORK	Completed or not Completed	CHARGE		CR.
			Acct. No.	District	Class No.
← 3/4" →	← 2 3/4" →	← 9/16" →	← 1/4" →	← 7/16" →	← 3/8" →
THREE SPACES PER INCH					

Form M. W. 1101.

USED ON EACH JOB

By________________________________Foreman of Bridges.

MATERIAL						
Number Articles	DESCRIPTION	Size	Quantity	Price	Amount	
11/16"	1 7/8"	3/4"	9/16"	3/8"	7/16"	7/16"

Size 8x13 inches

Form M. W. 701

A. B. & C. R. R. Co.

BRIDGE DEPARTMENT TOOL REPORT

____
(Gang or District)

____________________DIVISION. For________________ending________________19___

TOOLS	ON HAND ____1ST	RECEIVED	SENT TO SHOP FOR REPAIRS	BROKEN OR WORN OUT	ON HAND	TOOLS	ON HAND ____1ST	RECEIVED	SENT TO SHOP FOR REPAIRS	BROKEN OR WORN OUT	ON HAND
← 1.″5 →	←0.″5→	←0.″5→	←0.″5→	←0.″5→	←0.″5→	← 1.″5 →	←0.″5→	←0.″5→	←0.″5→	←0.″5→	←0.″5→
THREE SPACES PER INCH											

The above statement is correct:

....
Foreman of Bridges.

Correct: ....
Master Carpenter

Form M. W. 701.

A. B. & C. R. R. Co.

....
(Gang or Dist.)

...............DIVISION

BRIDGE DEPARTMENT TOOL REPORT

For.........Ending ....19..

Foremen are required to make the above report ....and forward same to Master Carpenter, who will, after examining, approve it and forward to Division Engineer.

To be filed in the office of Division Engineer.

SPECIFICATIONS FOR FORM M. W. 701.

Form as here shown. Size 8x13 inches. Vertical ruling, red; horizontal ruling, blue.

Size 8x13 inches. Form M. W. 1102.

A. B. & C. R. R. Co.

____________________Division

STRUCTURE REPORT

The following material was used____
(State location of structure definitely.)

____

Work authorized____________ Commenced____________ Finished____________

KIND OF MATERIAL	UNIT	QUANTITY	PRICE	AMOUNT	
←4.″2→	←0.″7→	←1.″0→	←0.″5→	←0.″8→	←0.″8→
KIND OF LABOR	HOURS				
OTHER CHARGES					

THREE SPACES PER INCH

The above statement is correct:

....
Division Engr.

Form M. W. 1102.

A. B. & C. R. R. Co.

................DIVISION

STRUCTURE REPORT

For..........Ending...........19..

SPECIFICATIONS FOR FORM M. W. 1102.

Form as here shown. Size 8x13 inches. Vertical ruling, red; horizontal ruling, blue.

Size 8x13 inches. Form M. W. 703.

A. B. & C. R. R. Co.

SUMMARY CURRENT BRIDGE INSPECTION REPORT.

For__________________________19___

Bridge No. or Structure	Kind of Structure	Day of Month Insp't'd	Condition	Action taken or Recommendation

Date_______________190__ ________________________

NOTE – This report to include all bridges and structures inspected during the period covered by the report.

Form M. W. 703.

A. B. & C. R. R. Co.

..............DIVISION

SUMMARY CURRENT

BRIDGE INSPECTION REPORT

For..........Ending..............19..

Foremen are required to make the above report..........and forward same to Master Carpenter, who will, after examining, approve it and forward to Division Engineer.

To be filed in the office of Division Engineer.

SPECIFICATIONS FOR FORM M. W. 703.

Form as here shown. Size 8x13 inches. Vertical ruling, red; horizontal ruling, blue.

Size 11x8 inches.

Form M. W. 704.

A. B. & C. R. R.

GENERAL BRIDGE

__________________________________**Division**

From__________________________ **To**____________________________

Bridge No. or Structure	Location	Kind of Structure	Bridge Data	Date Inspected

SPECIFICATIONS FOR FORM M. W. 704.

Form as here shown. Size of page, 5½x8 inches. To be issued in book form for field use, and on separate sheets for office use. Vertical ruling, red; horizontal, blue.

INSPECTION REPORT.

For ____________________________________

Inspected by ____________________________________ 19

General Condition, Description of work required, Recommendations.

Size 5¼ x 8 inches. Form M. W. 702.

Report No.__________

A. B. & C. R. R. Co.

__________________Division

CURRENT BRIDGE INSPECTION REPORT

I have to-day inspected____

at ____

and find its condition as follows:

____

____

The following work is required to maintain structure in good condition:

____

____

The following work must be done to keep the structure safe:

____

____

____

Inspector.

Date,______________________191

NOTE.—Make separate report for each bridge or structure inspected. Send report to the______________of the Division. Report by telegraph to the______________and the Superintendent of the Division all serious defects that require attention.

SPECIFICATIONS FOR FORM M. W. 702.
Current Bridge Inspection Report.
Form as here shown. Size 5¼x8 inches. All letters black.

*RIGHT-OF-WAY MAPS.

(1) Right-of-way maps should show the state, county, township, town or city; the right-of-way alinement complete; the station plusses of the crossing of all important land or property lines and streets, and the widths of streets and alleys which intersect the right-of-way, with the distance to all permanent land or street and alley corners. The angle which the center line of the road makes with the property line; the number of the right-of-way sheet; the points of the compass; the scale and date of the map; the boundaries of the several parts of the land owned by the company, and the width of right-of-way, particularly at those points where the widths change; any additions or sub-divisions of towns or cities, with numbers and sizes of lots and blocks, and names of streets. It should show all main tracks, side tracks and structures that were built in connection with the original construction of the road; the exact location of all crossings of steam, electric or other roads. Where the original right-of-way has been released or abandoned, the map should show the exact location of the center line of the original track.

(2) On or near each part of the land on the right-hand side of each map should be shown the deed custodian's number; the name of the grantor and grantee, reference to mileposts, kind of instruments, date and book and page where recorded. This also includes reference to long-term leases, franchises, ordinances and grants concerning use of land.

(3) The original right-of-way map should be traced, and the tracing filed away for a permanent record of the conditions existing at the time the railway was completed. The map from which this tracing is made should be corrected from time to time as changes are made in important tracks and structures, which are of value as reference to the right-of-way boundaries as well as any transfers of property made to and from the railway company.

(4) The property of adjacent railways or of subsidiary and associated companies should be shown in different colors.

(5) It is important to show on the original right-of-way map a profile of the same horizontal scale, and with the same station numbers as the map and of a suitable vertical scale, which profile should show the original subgrade, the location, character and size of opening of each bridge, waterway or under-crossing, and the original surface of the ground.

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* Adopted, Vol. 9, 1908, pp. 663, 664, 667, 668, 676-686; Vol. 11, 1910, pp. 1100, 1103, 1141, 1142.

Form M. W. 1900.

RIGHT-OF-WAY MAPS.

365

HENRICI & DUSS, TRUSTEES,
To
P. & L. E. R. R.,
Beaver Falls, Beaver Co.
W. Leed.

Feb. 6, 1892. Rec. 142-398.
Con., $2,100. Slopes, None.

Description.

Lot 22, 23, 24, b'd n by lots of Darragh, Fetterman and Porter, e by Lincoln alley, s by 17th st, w by 2d ave.

Conditions, None.

366

J. S. DARRAGH ET AL.,
To
P. & L. E. R. R.,
Beaver Falls, Beaver Co.
Con. Pro.
No. 271, June, 1883.

Con., $4,309.28. Slopes. None.

Description.

60 ft. wide through property. Plot shows 30 ft. each side of C. L. from Economy addition to Henrici and Lenz. Being grantors 13-24 undivided interest in same.

Conditions, None.

367

H. W. HARTMAN
To
P. & L. E. R. R.,
Beaver Falls, Beaver Co.
R. of W. Deed.

July 10, 1889. Rec. 122-106.
Con., $8,000. Slopes, 2d P., yes.

Description.

First Par.—B'd s by Harmony Society, e by Beaver River, n by Mrs. Metzgar, w by a line 30 ft. and part with N. B. C. L. and in addition so much as shall be necessary for R. of W. for siding to Paper Mill.

Second Par.—60 ft. wide from Paper Mill on s to Harmony Society on n, as shown by plot (no plot attached). Being grantors int. in above parcels.

Conditions.

Not to interfere with dam, right to transmit power under tracks, water wheels, two road crossings, to enlarge culvert, access to dam to repair same, 10 ft. to be reserved by grantee for siding above dam and w of track. Not to extend slopes into river, release of old R. of W. interest of Jas. Darragh.

368

JAMES DARRAGH
To
J. M. SCHOONMAKER,
Beaver Falls, Beaver Co.
W. Deed.

Oct. 4, 1894. Rec. 147-233.
Con., $4,500. Slopes, None.

Description.

First Par.—Water lot 6, B'd n by lot 5, e by Beaver River, s by lot 7, w by R. of W. 120 ft. wide, extending to river.

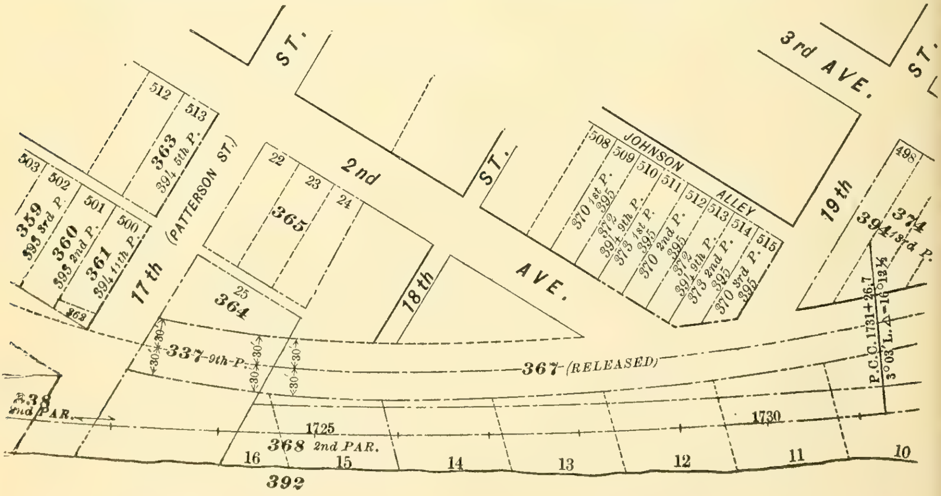
Second Par.—Water lots 15 and 16, B'd n by lot 14, e by Beaver River, s by line of Economy plan, w by R. of W.

Third Par.—Lots 543, 544, 545, B'd n by unnumbered lot, e by Beaver River, s by lot 542, having a front on R. of W. of 1,845 ft.

Fourth Par.—Lots 546, 457, B'd n by lot 548, e by river, s by unnumbered lot, w by R. of W., 123 ft.

Fifth Par.—Unnumbered lot, B'd n by lot 546, e by river, s by lot 545, w by R. of W., 61.5 ft.

Conditions, None.


ST.
2nd
ST.
AVE.
3rd AVE.
ST.
512
513
363
394 5th P.
(PATTERSON ST.)
503
502
501
500
359
395 3rd P.
360
395 2nd P.
361
394 11th P.
362
17th
22
23
24
365
25
364
18th
508
509
510
511
512
513
514
515
JOHNSON ALLEY
370 1st P. 395
372 394 9th P.
373 1st P. 395
370 2nd P. 395
372 394 9th P.
373 2nd P. 395
370 3rd P. 395
19th
498
374
394 3rd P.
30'
337 9th P.
367 (RELEASED)
P.C.C. 1731+26.7
3°03' L. Δ=16°12½'
338 2nd PAR.
1725
1730
368 2nd PAR.
16
15
14
13
12
11
10
392

SPECIFICATIONS FOR FORM M. W. 1900.

Right-of-Way Maps.

Maps showing right-of-way in cities and boroughs should be drawn to a scale of 100 ft. to 1 in. Maps showing right-of-way outside of municipalities may be drawn to a scale of 400 ft. to 1 in. They should be prepared, generally, as shown in the illustration. They should be made in separate sheets for convenient handling, and the width of sheets as a rule should not exceed 18 in. The length of sheets will be determined generally by the size of the printing frame.

Right-of-way sheets may be preserved in one of three ways:

(1) The sheets may be bound together into an atlas.

(2) They may be bound loosely in board covers, so that the sheets may be easily removed and corrected and replaced.

(3) They may be preserved as separate sheets and filed in regular order.

Form M. W. 2000

A. B. & C. R. R. Co.

MAIN LINE. REGISTER OF TITLE DEEDS. WAYNE COUNTY, MICHIGAN.

No.	Township.	City.	Sub-Div'n.	Sec.	Town'p	Range.	Block.	Lots.	Description.	Grantor.	Grantee.	Date of Convey-ance.	Consid-eration	Length	Width.	Area.	RECORDED.			Kind of Deed	Conditions.
																	B'k	Page.	Date.		
												M. D. Y.							M. D. Y.		
41	....	Detroit	....	..	..	....		16, 17,18	N. E. Cor. 4th and Front	Catherine H. Jones.	M. C. R. R.	Apr. 16, '47.	$2,300	97.48	60	1.34	31	274 275	Sept. 14,'47.	W.	None.
43	....	"	....	..	..	....	H	25-26	North of Front....	J. Halbert and Wife	"	Mar. 5, '47.	600	86.44	40	.79	31	273 274	" " "	W.	"
55	....	"	....	..	..	....	K	1-2	S. W. Cor. 4th and Front	Lewis Cass and Wife	"	Sept. 8, '47	19,000	......	......	.46	31	278 280	" " "	W.	"
40	Springwells.	"	....	..	..	....	..	Water Lot 2, 3	Bounded E.'ly by Canal Bank, W. Ann Hunt, N. Woodbridge St., S. by channel....	J. Mullet and Wife	"	Apr. 16, '47,	5,200	400	169.5	1.55	30	112 113 114	Apr. 20, '47.	W.	....
255	"	"	....	..	..	....	..	....	Triangular piece S. E. Cor. 12th and Woodbridge St...............	M. C. R. R.	Fort St. Union D.	Dec. 29, '90.	2,900	250	2.25	....	....	......	....	C.	....
8	"	"	....	..	..	....	..	....	Bounded W.'ly by Henry Stanton, E.'ly by Peter Godfrey	Farm'r and Mech Bank J. A. Wells and Wife	M. C. R. R.	Jan. 21, '47.	200	820	140	2.63	29	338–9 340	Jan. 21, '47.	W.	Fences, crossing, gates, etc.
250	"	"	Clarks.	..	..	....	..	120	S. ½ of E. ½ of E. ½ of P. C. 77....	H. Warren and Wife	"	Apr. 30, '02.	1.00	......	......	.063	569	292	May 10, '02.	Q. C	....
106	Dearborn....	....	....	29	2s	10 E	..	....	W. ½ of N. E. ¼ ..	A.Clay and Wife.....	"	June 1, '72.	75.00	1350	20	0.62	162	270	June 3, '73.	W.	....
12	Nankin......	....	....	31	2s	9 E	..	....	W. ½ of S. E. ¼...	C.W. Brink	St.of Mich.	Mar. 3, '41.	1.00	205	100	0.47	20	595–6			
70	"	....	....	31	2s	9E	..	....	W. ½ of S. W. ¼ ..	Wm. Bell and Wife	M. C. R. R.	Feb. 25, '48.	1.00	1470	100	3.37	32	563	Mar. 3, '43. Mar. 29, '48.	W. W.	R. R. Purposes, ...
33	VanBuren...	....	....	5	3s	8E	..	....	E. ½ of N. W. ¼..	B. Cotton and Wife	"	Jan. 8, '47.	1.00	1270	100	2.92	A	504	Jan. 13, '47.	W.	....
94	Canton......	....	....	35	2s	8 E	..	....	N. of and adj. Rt. of Way in S.W.¼	L. Sterling and Wife	"	Jan. 10, '59.	1.00	490	228	2.45	76	360	Jan. 22, '59.	W.	R. R. Purposes.

SPECIFICATIONS FOR FORM M. W. 2000.

Register of Title Deeds.

Form as shown; size of page, 12x28 in.; to be in book form, on heavy white ruled paper; horizontal ruling to be blue; vertical ruling to be red. (Form shown is two-thirds reduction.)

Deeds are filed with the Chief Engineer, the Real Estate Agent, or the Secretary of a railway company, according to individual practice.

The custodian of deeds should keep a Register of Title Deeds, in accordance with the form illustrated.

Deeds should be numbered consecutively, No. 1, 2, 3, etc., in the order of their receipt by the railway company; then forwarded to the proper officer to record on right-of-way maps; then returned by the Chief Engineer to the custodian of deeds with notation thereon that the deed has been properly entered, after which all deeds should be filed in numerical order in a fireproof vault.

CONTRACT AND LEASE RECORD.

Form M. W. 2001.

A. B. & C. R. R.

CONTRACTS AND LEASES

Number	Name of Road	With Whom	Nature of Document		Date	Expires	No. of Canceled Contract	Memoranda

100 Pages

RECEIPTS FOR CONTRACTS AND LEASES REMOVED FROM FILES.

RECEIPTS FOR CONTRACTS AND LEASES REMOVED FROM FILES.

Number	Name of Road	With Whom	Receipt	When taken	When returned		Number	Name of Road	With Whom	Receipt	When taken	When returned

80 Pages

REFERENCES TO CONTRACTS AND LEASES, SHOWING DATE OF EXPIRATION

REFERENCES TO CONTRACTS AND LEASES, SHOWING DATE OF EXPIRATION

JANUARY																		FEBRUARY																
1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913		1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913

8 Pages

SPECIFICATIONS FOR FORM M. W. 2001.

Contract and Lease Record.

The custodian of leases should keep a Contract and Lease Record Book, containing in the body of the book a full record of the lease in accordance with the form illustrated.

In the back part of the book twelve pages for the twelve months should be ruled into columns for years.

Leases should be numbered and filed in numerical order, by road, branch or division, in a fireproof vault.

Immediately after the receipt of a lease it is entered in the body of the book; the lease number should be entered under the year on the proper month page when it expires.

The names of the lessees should be indexed alphabetically in the front of the book, and each lease should be indexed by the station name.

A few pages in the back of the book should be used for the purpose of keeping a record of the leases removed from the files.

*TRACK MAPS.

(1) Track Maps should show all physical conditions pertaining to the construction and operation of the railway in the limits of the right-of-way, without reference to title or ownership. They should show all main sidetracks, their alinement, distance between them, and capacity in cars; all buildings upon the right-of-way and adjacent thereto, dimensions and character thereof and location with reference to main or sidetracks; bridges, culverts, water stations, coaling plants, turntables, shop buildings, water mains, conduits, wire lines of all kinds and supports, fences, street car and other railway crossings, and the angle they make with the railway track; sewers, signals of all kinds and physical conditions on the property. Important structures on such maps should be located by chainage numbers and plusses.

(2) They should be corrected whenever any changes are made in any of the features shown thereon, and at stated periods a corrected copy sent to the proper office.

(3) It is recommended that a scale of 100 ft. to the inch be used for such maps except in territories of large industrial development, where varying scales may be used to suit local conditions.

(4) Track Maps should show plainly the meridian, scale, original date and date corrected.

(5) The conventional signs adopted by this Association should be used where it is possible and convenient.

(6) On Track Maps drawn to a scale of 1 in. equals 50 ft. or less, tracks should be represented exclusively by double lines.

(7) On Track Maps drawn to a scale of 1 in. equals 200 ft. or more, tracks should be represented exclusively by single lines.

(8) On Track Maps drawn to a scale of 1 in. equals 100 ft.

(a) On maps representing preliminary studies and designs of proposed track layouts, tracks should be represented by single lines, except that double lines may be used where considered necessary to show turnout details.

(b) On maps representing completed work, station plats and permanent records, tracks should be represented by double lines.

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*Adopted, Vol. 9, 1908, pp. 664, 665, 668, 669, 686-690; Vol. 10, 1909, pp. 835-837, 870, 871.

Form M. W. 501

A. B. & C. R. R. Co.

MONTHLY TRACK MATERIAL REPORT.

Division

Section No.

For Month Ending 191

Column Nos. → 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Description of Material	Unit	On Hand at date of last Report	Received during the Month			Total to Account for	Used and Shipped during the Month					Total Disposed of	On Hand at date of this Report
			By Shipment	Taken Out of Track	From Track Taken up		Repairs		New Tracks		Shipped Away		
							Main Track	Sidings					
Rail — new — 1st. Class lbs. per yard.	Feet												
,, ,, ,, ,, ,, ,, ,,	,,												
,, ,, 2nd. Class ,, ,, ,,	,,												
,, ,, ,, ,, ,, ,, ,,	,,												
Rail — relaying — ,, ,, ,,	,,												
,, ,, ,, ,, ,,	,,												
,, ,, ,, ,, ,,	,,												
	,,												
Scrap Rail — lengths 6ft. and over — lbs. per yard.	,,												
,, ,, ,, ,, ,, ,, ,, ,, ,,	,,												
,, ,, ,, under 6 ft. ,, ,, ,,	,,												
Scrap — Frog — Switch and Guard Rails	,,												
Scrap — Miscellaneous track	Pounds												
Cross Ties — 1st. Class	Number												
,, ,, ,, ,,	,,												
,, ,, 2nd. Class	,,												
,, ,, ,, ,,	,,												
Switch Ties — turnout and Crossover — (Fill out space on back.)	Lin'r feet												
Bolts — Track —	Kegs												
,, ,,	,,												
R. R. Spikes.	,,												
,, ,,	,,												
Tie Plates — # Intermediate No. Joint, No.	Number												
,, ,, # ,, ,, ,, ,,	,,												
,, ,, # ,, ,, ,, ,,	,,												
Nut Locks — diameter of hole	,,												
,, ,, ,, ,, ,,	,,												
Rail Braces #	,,												
,, ,, #	,,												
,, ,, #	,,												
Tie Plugs —	,,												
	,,												
Angle Bars — weight drilling	Pairs												
,, ,, ,, ,,	,,												
,, ,, ,, ,,	,,												
,, ,, ,, ,,	,,												
,, ,, ,, ,,	,,												
,, ,, ,, ,,	,,												
,, ,, ,, ,,	,,												
Angle Bars — Offset — from to	,,												
,, ,, ,, ,, ,,	,,												
,, ,, ,, ,, ,,	,,												
Angle Bars — Insulated — weight — # drilling	,,												
,, ,, ,, ,, # ,,	,,												
,, ,, ,, ,, # ,,	,,												
,, ,, ,, ,, # ,,	,,												
Fibre End Posts — weight —	Number												
,, ,, ,, ,,	,,												
Frogs (Analysis of balance on hand at end of month) Kind No. Weight New or Old R.H. or L.H.	,,												
	Number												
	,,												
	,,												
	,,												
	,,												
Switches (Complete) Kind Length Weight New or Old	,,												
	,,												
	,,												
	,,												
	,,												
Extra Switch Points	,,												
	,,												
	,,												
	,,												
Slip Switches — weight No.	,,												
Guard Rails ,,	,,												
,, ,, ,,	,,												
,, ,, ,,	,,												
Switch Rods — Insulated	,,												
,, ,, Plain.	,,												
Slide Plates — with braces — weight #	,,												
,, ,, ,, ,, ,, #	,,												
,, ,, plain ,, #	,,												
,, ,, ,, ,, #	,,												
Switch Stands — Name High or Low	,,												
,, ,, ,, ,, ,, ,,	,,												
,, ,, ,, ,, ,, ,,	,,												
Switch Latches	,,												
Switch Locks —	,,												
Frog and Crossing Bolts.	,,												
R. R. Crossings — for Crossing weight #	,,												
Switch Lamps	,,												
Signal Lamps	,,												
Crossing Plank	Lin'r feet												
Crossing Spikes	Pounds												
Salt	Barrels												
Oil — Headlight	Gallons												
,, Signal	,,												
,, Lubricating	,,												
Waste	Pounds												
Pipe — Terra Cotta — size	Lin'r feet												
,, ,, ,, ,,	,,												
Iron Pipe ,,	,,												
Fence Posts.	Number												
Fence Boards.	Ft. B.M.												
Wire Fencing —	Rods												
Cattle Guards — Iron Wood	Number												
	,,												
	,,												

Checked and found correct

Supervisor of Track.

The above account is correct

Section Foreman.

SPECIFICATIONS—Size, 14x17 inches. Ruling, Horizontal—single lines, blue; parallel lines, red; Vertical, black or blue.

REMARKS:

Form M W. 501

A. B. & C. R. R.

.........................Division

MONTHLY TRACK MATERIAL REPORT

Section No. . . . .

Month of . . . . 19. . .

INSTRUCTIONS.

1. The Section Foreman must keep in a small blank book a daily record of all materials used.

2. He must also keep in the space provided on the back of this blank a daily record of all materials received and shipped.

3. He must close his account on the ......th of each month, and forward the report so as to reach the Supervisor not later than the morning of the . .... th of each month.

4. Column No. 14 must show the material actually on hand on the day the report is made.

5. The Supervisor must check the report, sign it and send it to the Division Engineer so as to reach him on the morning of the ......th.

TO BE FILED IN OFFICE OF DIVISION ENGINEER.

Daily Record of Material "Received by Shipment" and "Shipped Away"

Material Received				Material Shipped Away			
Date	Quantity	Description	From Whom Received	Date	Quantity	Description	To Whom Shipped

Number of Sets of Switch Ties on hand at end of Month

	Turn-outs							Cross-overs			Slips		R.R. Cross-ing	
	No. 4	No. 6	No. 8	No.10	No.12	No.14	No.	No.8	No.10		No.__	No.__		
Sets Ties - New														
" " - Old -														
Total Number														

Number and Length of Extra pieces of Switch Ties on hand at end of Month

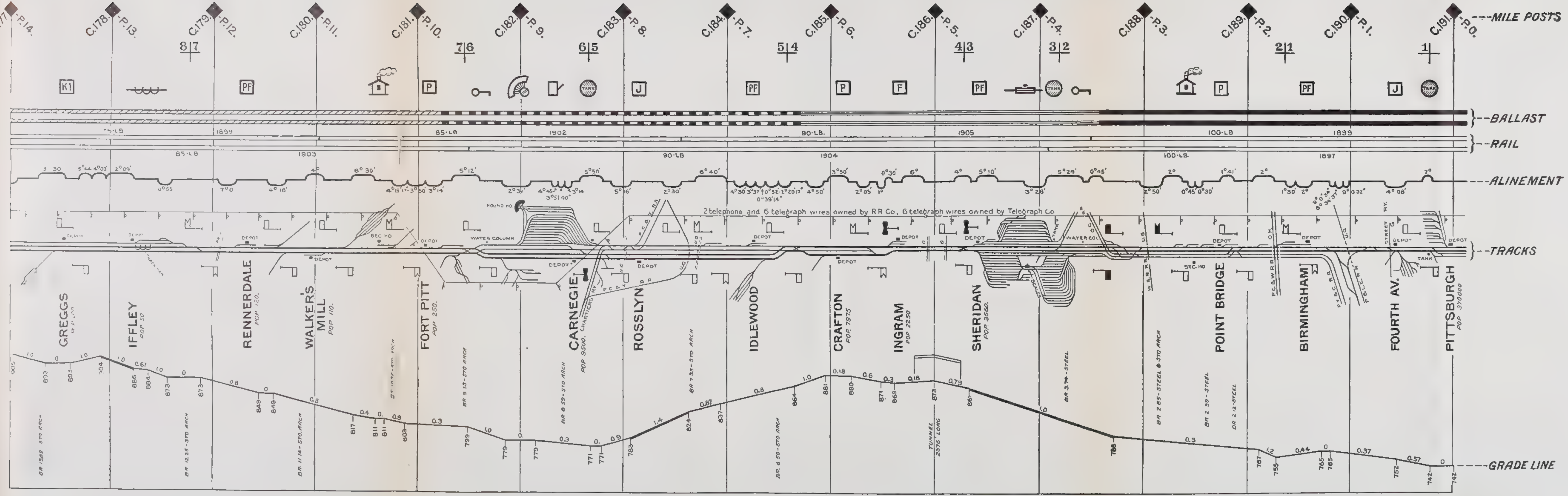
Lengths	8'9"	9'0"	9'3"	9'6"	9'9"	10'0"	10'3"	10'6"	10'9"	11'0"	11'3"	11'6"	11'9"	12'0"	12'3"	12'6"	12'9"	13'0"	13'3"	13'6"	
Number Pieces - New																					
" " - Old																					
Lengths	13'9"	14'0"	14'3"	14'6"	14'9"	15'0"	15'3"	15'6"	15'9"	16'0"	16'3"	16'6"	16'9"	17'0"						21'6"	
Number Pieces - New																					
" " - Old																					

FORM M. W. 2002.

TRACK CHART.

Form M. W 2002

TRACK CHART


C.177 P.14
C.178 P.13
C.179 P.12
C.180 P.11
C.181 P.10
C.182 P.9
C.183 P.8
C.184 P.7
C.185 P.6
C.186 P.5
C.187 P.4
C.188 P.3
C.189 P.2
C.190 P.1
C.191 P.0
MILE POSTS
8|7
7|6
6|5
5|4
4|3
3|2
2|1
1
KI
PF
P
J
F
TANK
BALLAST
75-LB
1899
85-LB
1902
80-LB
1905
100-LB
1899
RAIL
85-LB
1903
90-LB
1904
100-LB
1897
ALINEMENT
2 telephone and 6 telegraph wires owned by R.R. Co. 6 telegraph wires owned by Telegraph Co.
ROUND HO
DEPOT
SEC HO
WATER COLUMN
WATER COL
TRACK PAN
P.C.& Y. R.R.
CHARTIERS RY
SCALES
W. & B. R.R.
P.C.& W. R.R.
P.V.& C. R.R.
P.& L.E. R.R.
STREET RY
TANK
TRACKS
GREGGS
IFFLEY POP 50
RENNERDALE POP 120.
WALKER'S MILL POP 110.
FORT PITT POP 250.
CARNEGIE POP 9500.
ROSSLYN
IDLEWOOD
CRAFTON POP 7975
INGRAM POP 2250
SHERIDAN POP 3660.
POINT BRIDGE
BIRMINGHAM
FOURTH AV.
PITTSBURGH POP 370000
BR 13.89 STO ARCH
BR 12.25-STO ARCH
BR 11.14-STO. ARCH
BR 9.53-STO ARCH
BR 8.59-STO ARCH
BR 7.33-STO ARCH
BR. 6.50-STO. ARCH
TUNNEL 2376' LONG
BR 3.74-STEEL
BR 2.85-STEEL & STO ARCH
BR 2.39-STEEL
BR 2.12-STEEL
905
893
893
904
886
884
873
873
849
849
817
811
811
803
799
779
779
771
771
783
824
837
864
881
880
871
869
873
861
788
767
755
765
765
752
742
742
GRADE LINE

—EXPLANATIONS.—

Track Scales
Round House
Pole Wire Line
Water Tank
Track Pan
Water Column
Section Dwelling
Coaling Station
Passenger Station P Freight Sta. F Pass. & Frt. Sta. PF
Telegraph Office in Station J
Telegraph Office in Tower KI
Street and Public Road Crossings
Private Road Crossings
Road Crossings on Grade
Road Crossings under Grade
Road Crossings overhead
Section Foremen's Limits 3|2
Alinement 4° 2° 4° curve to right. 2° " " left.

—SIGNALS—

Home Interlocking
Distant "
Home Automatic
Distant "
Home Disc
Distant "
Train-Order

NOTE: The foot of the mast shows the exact location of the signal.

Mile Posts C.179. P.12.

—BALLAST—

Broken Stone
Slag
Screenings
Gravel
Cinders
Chats
Sand
Burnt Clay
Earth

—RAIL—

100-Lb. Black
90 " Red
85 " Yellow
80 " White
75 " Green
70 " Purple

Note: Re-rolled Rail is shown in broken line.

—SCALES—

One Inch = 4000 Feet: Horizontal Scale for Profile, Alinement, Tracks and Charts
One Inch = 120 Feet: Vertical Scale for Profile

NOTE: Ruling Grades are shown on the Profile in heavier lines than other grades
Numbers on Grade Line show the percent. of rise or fall
Population shown to right of station names.

*MONTHLY TRACK MATERIAL REPORT.

The Monthly Track Material Report, Form M. W. 501, containing the necessary information for keeping a proper check on material received and used, is recommended.

†PROGRESS PROFILE.

A profile showing complete information respecting the rate of progress of work pertaining to the different features of a railway is necessary, and the standard "Progress Profile," form M. W. 2001, is recommended.

‡TRACK CHART.

A Track Chart showing complete information respecting the grade, alinement and other physical features of a railway is necessary, and the "Track Chart," form M. W. 2002, is recommended.

§AUTHORITY FOR EXPENDITURE.

Construction, addition or betterment work should be authorized in accordance with a reasonable and simple system, involving the preparation of estimates of cost and the formal authorization of the expense by executive officers, and forms M. W. 1107, M. W. 1108 and M. W. 1109 are recommended.

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* Adopted, Vol. 6, 1905, pp. 650, 651, 657, 659, 661-663, 668-672.
† Adopted, Vol. 7, 1906, pp. 278, 280, 328, 329.
‡ Adopted, Vol. 7, 1906, pp. 278, 280, 328, 329; Vol. 10, 1909, pp. 834, 835,
§ Adopted, Vol. 8, 1907, pp. 111, 112, 114, 116-120, 132.

Size 8x13 inches. Form M. W. 1107.

Estimate No.__________

A. B. & C. R. R. Co.

*APPLICATION FOR EXPENDITURE.

________________DIVISION

Estimate based on Plan No.________ Dated________________19___

LOCATION____________________

DETAIL OF ESTIMATE	New Work or Additions		Betterments		Renewals or Replacements		Individuals & Companies	
TOTALS								

NOTE: Write in space below date of agreements, name of parties, etc., that are to be billed for items distributed to Individuals and Companies.

The above expenditure is respectfully recommended.

Correct________	Approved________	Approved________
(Title)________	(Title)________	(Title)________
Date________	Date________	Date________

SPECIFICATIONS FOR FORM M. W. 1107.

Size 8x13½ inches; horizontal lines, blue; vertical lines, red; to be printed on medium bond paper (white).

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* Adopted, Vol. 9, 1908, pp. 665-667, 669, 674, 675, 693, 694.

(Back of Blank.)

Enter in this space basis used for dividing estimate between betterments and renewals or replacements	Disposition of abandoned building or other structure

INSTRUCTIONS FOR USING THIS BLANK.

(1) When estimate is based upon plans, always refer to numbers and dates of plans.

(2) Observe the following rules in describing work:

(a) When additional buildings or other structures are to be built, begin your description with the word "New."

(b) When a building or other structure is to be built to replace an inferior one, or one of different kind, begin your description with the word "Replacing."

(c) In case of replacement, mention should be made of any variation from the original construction, such as:

Substituting stone for frame building.
Steel for wooden bridge, etc.

(d) When a building or other structure is reconstructed, restoring the original, use the word "Renewing."

(e) Under other conditions use a suitable word, such as:

Strengthening	(Bridges).
Changing	(Yard Tracks).
Altering	(Buildings).
Extending or Widening	(Wharves).
Improvement at	(Consisting of new standard 20x40 foot frame passenger station, renewing 30x50 foot standard frame freight station, altering yard tracks, strengthening bridges, etc.)

(3) CREDITS: When including in the estimate material which is to be used in temporary work, allow (under head of "Credits") an amount to cover estimated value of material to be recovered.

(4) On back of blank, in "Disposition" space, show disposition to be made of the abandoned buildings or other structures.

(5) This form to be submitted in..........by the original officer to the approving officer. (Estimates should be submitted as per special instructions of individual roads.) If estimate is approved, authority for performing work will be given on Form No. 1108.

(6) ESTIMATES should be numbered for identification.

Size 8x10½ inches. Form M. W. 1108.

A. B. & C. R. R. Co.

AUTHORITY FOR EXPENDITURE.

______________________________________19___

____

(Title of approving officer.)

..........................Estimate No...... Dated................191..

Charge to Construction................................	Charge Approved:
Additions..................................	In all Vouchers, Reports, etc., refer to
Replacements or Renewals.................	
Special....................................	AUTHORIZATION No...........
Individuals and Companies...............	
....	
....	....

This authority to be supplemented by Form 1109 at the discretion of the approving officer.

The expenditures under this authority must not exceed the amount authorized. Additional authority must be obtained in case of necessity.

This authority expires at the end of the year in which issued. If work is incomplete at that time, a new authority will be issued for the following year's expenditures.

Size 8x10½ inches. Form M. W. 1109.

A. B. & C. R. R. Co.

APPROPRIATION FOR EXPENDITURE.

_____________________________19____

......................Estimate No..........Dated....................191..

Charge to Construction..............................	Charge Approved: ....
Additions..................................	In all Vouchers, Reports, etc.,
Replacements or Renewals...............	refer to
Special..	AUTHORIZATION No...........
Individuals and Companies................	
....	
....	

The expenditures under this authority must not exceed the amount authorized. Additional authority must be obtained in case of necessity.

This authority expires at the end of the year in which issued. If work is incomplete at that time, a new authority will be issued for the following year's expenditures.

SPECIFICATIONS AND INSTRUCTIONS FOR USE OF FORMS M. W. 1107, 1108 and 1109.

Form M. W. 1107, size 8x13½ inches, to be printed on medium bond paper (white), should be used for submitting estimate of cost of work to the officer who issues the authority (form 1108) for doing the work. This form, when properly filled out, should show:

(1) A reference to the plan number.
(2) A brief and concise description and location of the work covered by the estimate.
(3) Estimate of cost in detail.
(4) Credits, if any, for material to be recovered, etc., such as salvage from false-work, temporary tracks, and in case of a renewal (which renewal is occasioned on account of a fire) the amount of insurance recovered, and anything else that is a proper credit to the job.
(5) Distribution of estimated cost as between New Work, Betterments, Renewals or Replacements and Individuals and Companies.
(6) Estimate will be signed by various officers in accordance with the prevailing organization.
(7) Reproduction cost of any building or other structure which is to be replaced. This information will be required by the officer determining the distribution of the expense.

A set of instructions governing the use of the form has been provided. Special attention is called to those covering the describing of work.

Form M. W. 1108, size 8x10½ inches, to be printed on medium bond paper. (yellow). Yellow paper is recommended so as to make this form distinctive.

This form should be used by the highest executive officer to convey to those interested the fact that the work is authorized and the estimate approved. This form, when properly filled out, should show:

(1) A brief and concise description and location of the work.
(2) Estimated cost, in a lump sum, which lump sum will be the total of the estimate, or estimates, as given on form 1107.
(3) Instructions as to whether form 1109 is to be submitted or not.
(4) A reference to the number, or numbers, of estimates (form 1107) which it covers, and an approved copy of the estimate (form 1107) should be attached to each copy of form 1108, issued for the information of all concerned.
(5) Distribution of expense as between Construction, Additions, Replacements, Special and Individuals and Companies.

This form does not authorize expenditures of money unless it bears a notation that form 1109 will not be required. The actual expenditures of money would be authorized on form 1109, except as above noted.

Form M. W. 1109, size 8x10½ inches, to be printed on medium bond paper (white), should be used by the proper officer to authorize expenditures of money for work authorized by form 1108.

This form, when properly filled out, should show:

(1) A brief and concise description and location of the work to be done.
(2) Total amount of form 1108, of which it is a part.
(3) The Engineer's estimate as covered in form 1108.
(4) A detailed or lump sum amount required for the job.
(5) Distribution of the expense.
(6) Number of the form 1108 against which it applies. A designating letter in addition to the number.
(7) And any other detail required by the company or approving officer.

Note.—For the general outline and description of method of using these blanks see Vol. 8, 1907, pp. 109-111.

Size 8 x 13 inches.

Form No. 1110

A. B. & C. R. R. Co.

*MONTHLY REPORT OF EXPENDITURES ON AUTHORIZATION.

FOR MONTH OF________________19

Authority No.________ Description________________________
Amount $________ of Work________________________
Location________ Date Begun________19___ Date Completed________19___

AUTHORITY		Expended During Current Month	Previous Expenditures	Total Expenditures to Date	Est. Expenditures for Ensuing Month	Total Est. Cost of Ensuing Month	Est. Cost of Completed Work	Increase	Decrease	Remarks
Item	Amount									

---

* Adopted, Vol. 9, 1908, pp. 665-667, 673, 691.

*RECORD COST OF WORK.

Size 14x17 in. Form M. W. 1111.

A. B. & C. R. R. Co.

General Description............................ Location..................
Authorization No.......... Total Amount Authorized $..................
Actual Cost $............ Work Began.....................................
Work Completed.............................. Remarks.....................
....

	Quantity	Unit		Price	Value	Total	Grand Total

SPECIFICATIONS FOR FORM M. W. 1014.
Size 14x17 in.; unruled; to be printed on medium bond paper (white).

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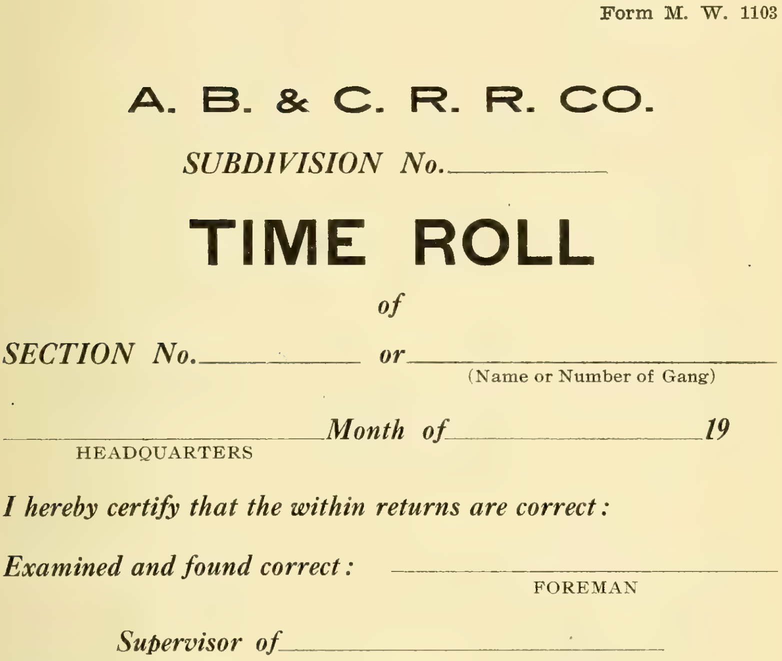
* Adopted, Vol. 9, 1907, 665-667, 669, 672, 693.

COVER PAGE OF FORM M. W. 1103, PROVIDING FOR SIGNATURE OF FOREMAN AND SUPERVISOR.



Form M. W. 1103

A. B. & C. R. R. CO.

*SUBDIVISION No.*__________

TIME ROLL

of

*SECTION No.*__________ *or*____________________
(Name or Number of Gang)

____________________ *Month of*________________ *19*
HEADQUARTERS

I hereby certify that the within returns are correct:

Examined and found correct: ____________________
FOREMAN

*Supervisor of*____________________

SPECIFICATIONS FOR FORM M. W. 1103.

Size of book, 5x8 inches. Form as shown, cover to be of three-ply manila paper; book proper to be on yellow paper; printing to be in black. Book to contain 12 pages. (Form shown is about one-half reduction.)

DAILY RECORD

RECORD OF TIME

NAME	CHECK No.	OCCUPATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

1. Spell names correctly. Write out first name and give middle initial. Enter check number in check number column.

2. Write "Paid by Certificate," when men have been so paid. If hired again, enter name a second time.

INSTRUCTIONS.

1. Enter the information daily.
2. Read the instructions at the bottom of pages 2 and 3.
3. Show under each day the hours of work of each kind done, including work done by Foreman.
4. The Summary on pages 14 and 15 must show all the work done during the month. It is obtained by collecting the work done each day. Show separately work done on main tracks, sidings, new or construction work of all kinds and for individuals or other companies.
5. The total hours each day must agree with the totals shown on pages 2, 3, 4, 5, 6 and 7.
6. The total of hours in Summary must agree with the total on page 7.

OF TIME.

Form M. W. 1103.

FOR MONTH OF____________________19_

18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL HOURS	RATE OF PAY		DEDUCTIONS	AMOUNT	WHERE PAYABLE
															Per Month	Per Hour			

3. Amounts due each man must be in even five (5), or ten (10), cents.
4. Time of monthly men, not working a full month: Multiply the rate per month by the number of days worked (including Sundays and holidays) and divide by the total number of days in the month.

RECORD OF WORK DONE ON DAYS OF THE MONTH

DAY	KIND OF WORK AND WHERE PERFORMED	HOURS
1		
2		
3		
4		
5		

4

NOTE.—Spaces to be provided for 31 days.

RECORD OF WORK DONE ON DAYS OF THE MONTH

DAY	KIND OF WORK AND WHERE PERFORMED	HRS.
31		

SUMMARY OF WORK DONE FOR MONTH

ITEMS	DISTR.	HOURS	RATE	AMOUNT

I certify the foregoing to be correct,

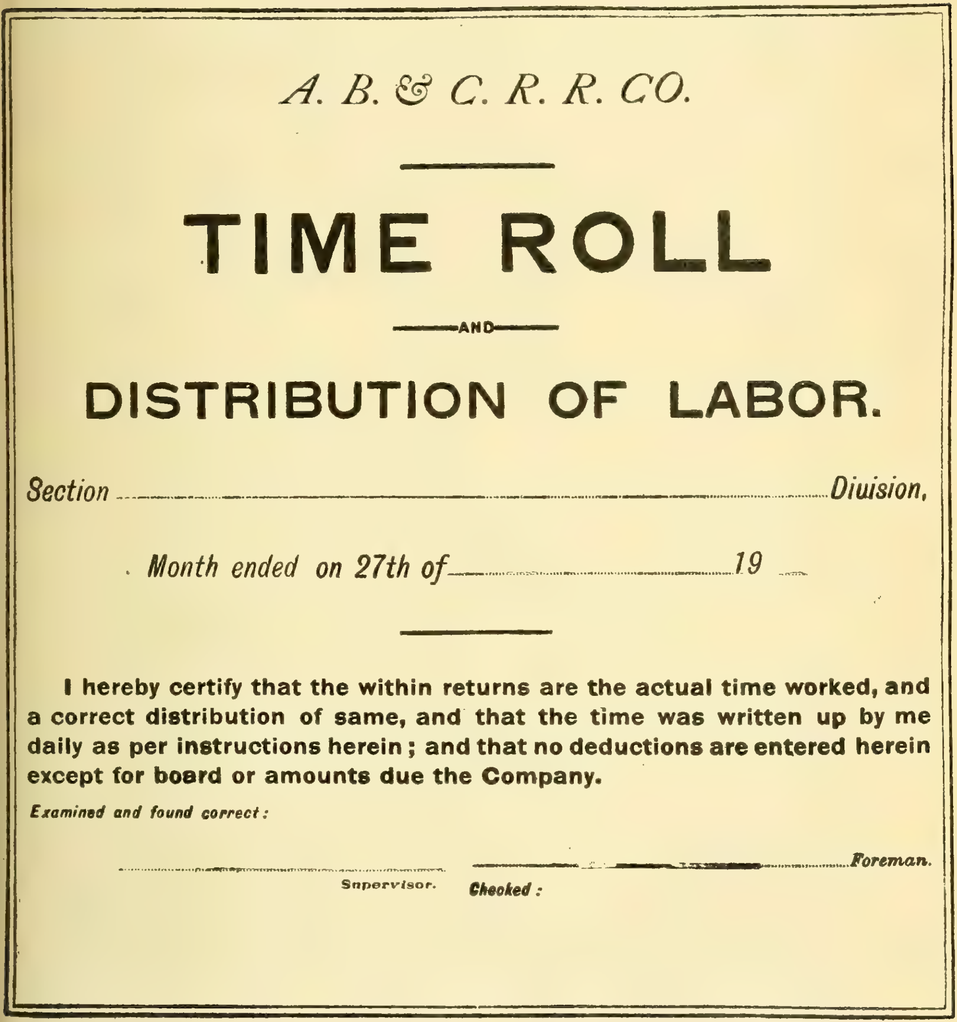
______________________*Foreman.*

Examined and approved,

______________________*Supervisor.*

FORM TO BE USED BY SECTION AND EXTRA GANGS.

Size 8½x9 in. Form M. W. 1104.



The outside cover **MUST** be filled up properly as to location and month and properly

A. B. & C. R. R. CO.

TIME ROLL

AND

DISTRIBUTION OF LABOR.

Section .... Diuision,

Month ended on 27th of .... 19 ....

I hereby certify that the within returns are the actual time worked, and a correct distribution of same, and that the time was written up by me daily as per instructions herein; and that no deductions are entered herein except for board or amounts due the Company.

Examined and found correct:

.. Foreman.

.. Supervisor.

Checked:

NOTE.—This Book may be carried in the pocket by folding at the line shown on back.

FORM FOR DISTRIBUTION SUMMARY—

DISTRIBUTION OF LABOR PERFORMED AS SHOWN ON PAGES 1 AND 2.

DISTRIBUTION OF LABOR.	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11

To be made out by Foreman.

TO BE MADE OUT BY FOREMAN.

_____*Division.* *Month ending 27th of*_____*19* —

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	TOTAL TIME	Account Number	
																	2	This column must be in accordance with the established Classification of Accounts.
																	4	
																	9	
																	10	
																	11	
																	12	
																	13	
																	14	
																	15	
																	16	
																	17	
																	18	
																	19	
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																	31	
																	32	
																	33	
																	34	
																	35	
																	36	
																	37	
																	39-40-41	
																	51 to 65	
																	92	
																	105-118-119	
																	135	
																	145	

To be made out by Accountant.

PAGE FOR SHOWING DETAILS OF WORK DONE BY TRACK

EXPLANATIONS.

REPAIRS WATER STATIONS			REPAIRS FUEL STATIONS			WORK EQUIPMENT REPAIRS		
DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME	DATES	GIVE NAME AND NUMBER	TIME

HANDLING COMPANY'S MATERIAL—COAL, WOOD, ICE OR ENGINE SAND

DATES	STATIONS	TIME	DATES	STATIONS	TIME	DATES	STATIONS	TIME

CLEANING STOCK PENS AND CHUTES			CLEANING STOCK CARS			TENDING SWITCH LAMPS			
DATES	STATIONS	TIME	DATES	STATIONS	TIME	DATES	LOCATIONS	TIME	

REPAIRS OF INTERLOCKERS			REPAIRS BLOCK SIGNALS			REPAIRS TO OTHER SIGNALS		
DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME

SIDINGS TAKEN UP.

DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME	DATES	LOCATIONS	TIME

ALL OTHER WORK ON EXISTING SIDINGS

DATES	LOCATIONS	NATURE OF WORK	TIME	DATES	LOCATIONS	NATURE OF WORK	TIME

DEPARTMENT ON WORK NOT CHARGEABLE TO TRACK WORK.

EXPLANATIONS.

BRIDGES, TRESTLES AND CULVERTS, PERMANENT				BRIDGES, TRESTLES AND CULVERTS, TIMBER							
		TIME				TIME				TIME	
DATES	NUMBERS	Main Tracks	Side Tracks	DATES	NUMBERS	Main Tracks	Side Tracks	DATES	NUMBERS	Main Tracks	Side Tracks

OVER AND UNDER GRADE CROSSINGS				HIGHWAY GRADE CROSSINGS				CATTLE GUARDS AND SIGNS			
		TIME				TIME				TIME	
DATES	NUMBERS	Main Tracks	Side Tracks	DATES	NUMBERS	Main Tracks	Side Tracks	DATES	NUMBERS	Main Tracks	Side Tracks

REPAIRS OF BUILDINGS.

DATES	KIND OF BUILDING AND WHERE LOCATED	TIME	DATES	KIND OF BUILDING AND WHERE LOCATED	TIME	DATES	KIND OF BUILDING AND WHERE LOCATED	TIME

REPAIRS AND RENEWALS OF EQUIPMENT.

ENGINES			PASSENGER CARS			FREIGHT CARS		
DATES	GIVE NAME AND NUMBER	TIME	DATES	GIVE NAME AND NUMBER	TIME	DATES	GIVE NAME AND NUMBER	TIME

DETAILS OF CHARGES TO OTHER THAN OPERATING ACCOUNTS.

10

FOR USE OF ACCOUNTANT

DETAIL OF CHARGES TO CONSTRUCTION, SUNDRY DISTRIBUTIONS AND ADDITIONS AND BETTERMENTS

ADDITIONS AND BETTERMENTS				SUNDRY DISTRIBUTIONS			
	AMOUNT				AMOUNT		
CONSTRUCTION	AMOUNT						

Cover page for Form M. W. 1105. This form to be used by B. & B., Fence, Telegraph, Signal, Water Service, and all other gangs except Section and Extra Gangs.

Size 8½x9 inches. Form M. W. 1105.

The outside cover MUST be filled up properly as to location and month and properly signed.

A. B. & C. R. R. CO.

TIME ROLL

—AND—

DISTRIBUTION OF LABOR

Gang No.……………………

______________________ **DEPARTMENT**

Month ending on ______________ *of* ______________ *19*

I hereby certify that the within returns are the actual time worked, and a correct distribution of same, and that the time was written up by me daily as per instructions herein; and that no deductions are entered herein except for board or amounts due the Company.

Examined and found correct:

……………………………………*Foreman.*

……………………………………
Supervisor.

Checked:

NOTE—This Book may be carried in the pocket by folding at the line shown on back.

TIME RECORD FOR FORMS M. W. 1104 AND 1105.

Page A.

.... —TIME ROLL. **Department.**

	NAME.	Occupation	28		29		30		31		1		2		3		4		5		6		7		8		9		10		11		12	
			A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
1																																		
2																																		
3																																		
4																																		
5																																		
6																																		
7																																		
8																																		
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14																																		
15																																		
16																																		
17																																		
18																																		
19																																		
20																																		
	TOTAL																																	
	The person checking this book will sign his Initials and Time of Inspection in the spaces below total line.																																	

TIME RECORD FOR FORMS M. W. 1104 AND 1105—Continued.

Page B.

..............................Division. **Month ended 27th of**..................................**19**....

13		14		15		16		17		18		19		20		21		22		23		24		25		26		27		TOTAL TIME	RATE OF PAY		AMOUNT OF WAGES		DEDUCTIONS		REMARKS
A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.		Per Month	Per Hour					

DISTRIBUTION PAGE FOR LABOR PERFORMED BY INDIVIDUALS WHERE

REPORT OF LABOR PERFORMED by...

	DESCRIPTION OF WORK PERFORMED Give numbers of all bridges, location and description of all buildings, location of bridge watchmen, location of fences, etc., etc.	28		29		30		31		1		2		3		4		5		6		7		8		9		10		11		12	
		A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
1																																	
2																																	
3																																	
4																																	
5																																	
6																																	
7																																	
8																																	
9																																	
10																																	
11																																	
12																																	
13																																	
14																																	
15																																	
16																																	
17																																	
18																																	
19																																	
20																																	
	TOTAL,																																

GANG IS NOT ALL EMPLOYED ON SAME PIECE OF WORK.

Form M. W. 1105.

________________Division. Month ended 27th of________________19

13		14		15		16		17		18		19		20		21		22		23		24		25		26		27		TOTAL TIME	RATE OF PAY		AMOUNT OF WAGES		DEDUC-TIONS		REMARKS
A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.		Per Month	Per Hour					

TIME RECORD OF TEAMS EMPLOYED.

Form M. W. 1104 and 1105.

RECORD OF TEAMS EMPLOYED. **Section No.**……………………………

	NAME.	Number of Teams	28		29		30		31		1		2		3		4		5		6		7		8		9		10		11		12	
			A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
1																																		
2																																		
3																																		
4																																		
5																																		
6																																		
7																																		
8																																		
9																																		
10																																		
11																																		
	TOTAL																																	

TIME RECORD OF TEAMS EMPLOYED.

Forms 1104 and 1105.

Division. Month ended 27th of .... 19....

13		14		15		16		17		18		19		20		21		22		23		24		25		26		27		TOTAL TIME	RATE OF PAY		AMOUNT OF WAGES	DEDUCTIONS	If Amount Exceeds $150.00 it should be paid by Voucher
A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.		Per Month	Per Hour			
																																			DRAFT or VOUCHER No.
																																			"
																																			"
																																			"
																																			"
																																			"
																																			"
																																			"
																																			"
																																			"
																																			"
																																			"

DISTRIBUTION SUMMARY (TO BE MADE OUT IN

Form M. W. 1105.

SUMMARY OF DISTRIBUTIONS.

DESCRIPTION OF WORK PERFORMED.	AMOUNTS CHARGEABLE											
The description given hereunder must agree with that shown on preceding pages.	1 and 2		3 and 4		5 and 6		7 and 8		9 and 10		11 and 12	

SUPERVISING OR ACCOUNTING OFFICE).

FROM PAGES					
13 and 14	15 and 16	17 and 18	19 and 20	21 and 22	

SUMMARY OF DISTRIBUTIONS.

AMOUNTS CHARGEABLE					
23 and 24	25 and 26	27 and 28	29 and 30	31 and 32	33

PAGE FOR EXPLAINING OVERTIME AND ERRORS IN RECORDING TIME.

Forms M. W. 1104 and 1105.

EXPLANATION OF OVERTIME.

EXPLANATION OF ERRORS.

INSTRUCTIONS ON INSIDE COVER OF FORMS M. W. 1104 AND 1105.

INSTRUCTIONS.

TO FOREMEN:

1. On the "Time Roll' the name of the foreman should be entered on the first line, and those of his men should be arranged thereunder in alphabetical order of their surnames. One given name of each man must be written in full.

2. Time worked should be entered as directed by superior officer.

3. All entries must be made by indelible pencil.

This book must be carried by the foremen and submitted for inspection to Roadmaster or Supervisor whenever request is made therefor. If foreman should leave his gang he should leave his book with assistant foreman, if one is employed, so book can be checked.

4. Distribution of time should be entered daily on pages 1 to 40 inclusive. Separate line should be used for each piece of work and time should be shown opposite each under correct date. Total of distribution for the month as shown on detail pages must agree with total amounts shown under "Amount of Wages" on pages A and B.

5. If a man is given an order for his time, write "Time Given" in the column headed "Remarks" on page B, on the same line with his name and time.

Form M. W. 1112.
Size

A. B. & C. R. R. Co.

Statement of Labor performed on { Section No. ______ / or by ____________________________ ________________ DIVISION Gang Located at ________________________ on Sub Div No ______________________ for month of ____________ 19___

	No	NAME	OCCUPATION	LOCATION	TIME EMPLOYED																														Total Time	Rate		Amount Earned	DEDUCTIONS			Amt. Payable	REMARKS
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	24	24	25	26	27	29	30	31		Mo.	Hr		For	In favor of	Amt.		
			Total Hours																																								
			Total Wages																																								
		Accounts Chargeable																																	Total Charges	★	★	★	★	★	★	★	
		Maintenance of Way and Structures:																																									
		1 Superintendence																																									
		2 Ballast																																									
		3 Other Track Material																																									
		6 Roadway and Track																																									
		7 Removal of Snow, Sand and Ice																																									
		8 Tunnels																																									
		9 Bridges, Trestles and Culverts																																									
		10 Over and Under Grade Crossings																																									
		11 Grade Crossings, Fences, Cattle-Guards and Signs																																									
		12 Snow and Sand Fences and Show Sheds																																									
		13 Signals and Interlocking Plants																																									
		14 Telegraph and Telephone Lines																																									
		16 Buildings, Fixtures and Grounds																																									
		17 Docks and Wharves																																									
		18 Roadway Tools and Supplies																																									
		19 Work Equipment—Repairs																																									
		Total M of W & S																																									
		Maintenance of Equipment:																																									
		Total M of E																																									
		Transportation Expenses:																																									
		72 Station Supplies and Expenses																																									
		78 Engine House Expenses Yard																																									
		87 Engine House Expenses Road																																									
		95 Train Supplies and Expenses																																									
		96 Interlockers, Block and Other Signals—Operation																																									
		98 Drawbridge Operation																																									
		99 Clearing Wrecks																																									
		Total Transp Expenses																																									
		General Expenses:																																									
		Total General Expenses																																									
		Total Operating Expenses																																									
		Fuel and Supplies:																																									
		Total Fuel and Supplies																																									
		Open Accounts:																																									
		Individuals and Companies																																									
		Total Open Accounts																																									
		General Accounts:																																									
		Additions																																									
		Betterments																																									
		Outside Operations																																									
		Acct. No. Sub. Acct. No.																																									
		Acct. No. Sub. Acct. No																																									
		Total Outside Operations																																									
		Other General Accounts																																									
		Real Estate Expenses and Repairs																																									
		Total Other General Accts.																																									
		Grand Total																																									

This can be modified to conform with Classification of Expense.

I hereby certify that the time made by each employe named herein and distribution to accounts chargeable correspond with actual work done as reported to me daily by Foreman ______________________________ on Form ______, and I have examined Foreman's Pocket Record of Time, Form ______, and find that total time and

Examined and approved:

★ Distribute Amounts chargeable to Main Line, Roads Merged, etc., and Branch Roads in these columns

Back of Form M. W. 1112.

INSTRUCTIONS.

1. Enter full name of each employe in each gang, and give proper occupation and location in respective columns. The time made by each employe must be recorded daily and show total time made at close of month. The time made during month, calculated at authorized rates, will give amount earned.

2. Supervisors must distribute time daily to the proper accounts, chargeable according to information given on Foreman's Report, Form ......, and care must be exercised so that at close of month the "Total Charges" will balance with the "Total Wages."

3. At the close of month Supervisors will apportion expense to Main Line, Roads Merged, etc., and Sundry Branch Roads, in accordance with the instructions of the road using.

4. This report must be carefully checked with Foreman's Pocket Time Book Form ......, and if there is any difference it must be located and proper adjustment made before this report is forwarded to ...... for approval.

5. This report, after being properly certified by Supervisor and examined and approved by ...., will be forwarded to the .... on the ...... of the month.

Form M. W. 1106.

A. B. & C. R. R. Co.

SUB-DIVISION No.______

Daily Report of Time Worked by Track Gang on Section No.______________________________

or________________________Gang at______________________Location___________________

For_____________Day of______________________19___

NAME	IDENTIFICATION NUMBER	OCCUPATION	RATE		DESCRIPTION OF WORK DONE								TOTAL TIME	AMOUNT To be filled in by Supervisor		REMARKS
			Mo.	Hrs.												
To be filled in by Supervisor.		Total Time " Wages														

Time and Extensions Entered by_______________

I certify that the persons named above were employed in the service of the A. B. & C. R. R. Co. as specified, and the time worked is correct.

Examined by______________

_________________Foreman.

See Instructions on back.

Back of Form M. W. 1106.

INSTRUCTIONS.

1. This Report will be made by the Foreman and forwarded to Supervisor on first train after completion of each day's work.

2. Care must be taken to write distinctly, give correct description of work done in space provided, and that the actual hours engaged by each man on each class of work is entered in proper column opposite his name. Foreman will also enter his own time in hours (total only).

3. Total time made daily by each employe must agree with his time as shown by Foreman's pocket time book, Form..........

4. Foreman will enter his name first, then follow with balance of gang.

5. Give below briefly a statement showing quantity of work done..................

....

....

....

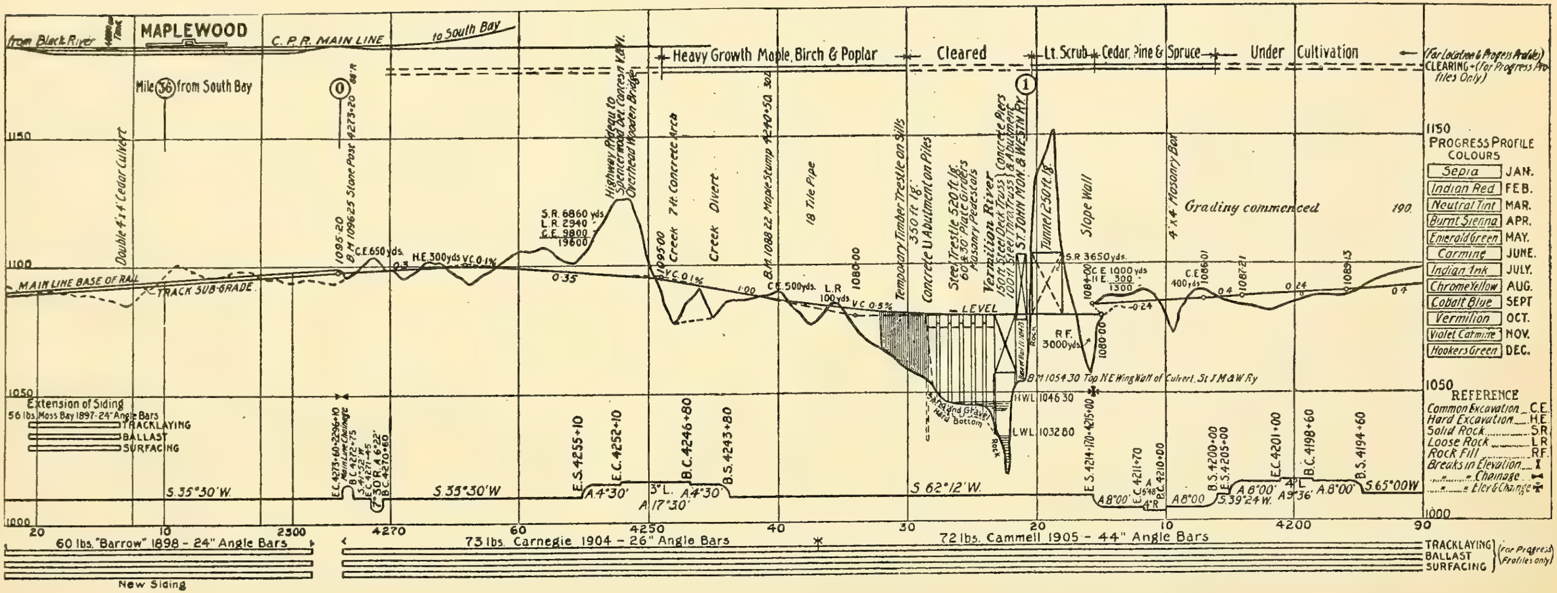
....

....

....

Form M. W. 2001

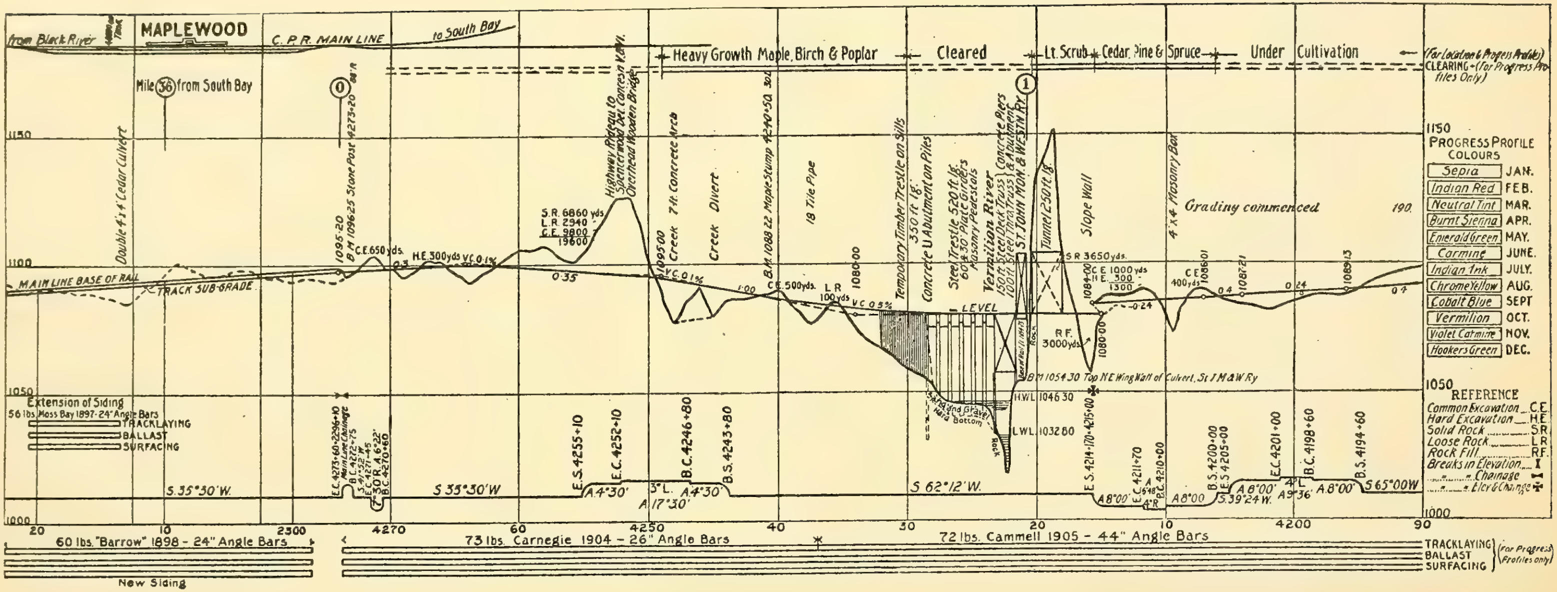
PROGRESS PROFILE.


from Black River
MAPLEWOOD
C. P. R. MAIN LINE
to South Bay
Mile 36 from South Bay
Heavy Growth Maple, Birch & Poplar
Cleared
Lt. Scrub
Cedar, Pine & Spruce
Under Cultivation
(For Location & Progress Profiles)
CLEARING (For Progress Profiles Only)
1150
1100
1050
1000
Double 4'x4' Cedar Culvert
MAIN LINE BASE OF RAIL
TRACK SUB-GRADE
1095·20
B.M. 1096·25 Stone Post 4273+20
C.E. 650 yds.
H.E. 300 yds
V.C. 0·1%
S.R. 6860 yds
L.R. 2940
C.E. 9800
19600
0·35
Highway Rideau to Spencerwood Del. Cons. V.&V.I.
Overhead Wooden Bridge
1095·00
Creek 7 ft. Concrete Arch
V.C. 0·1%
Creek Divert
B.M. 1088·22 Maple Stump 4240+50
1·00
C.E. 500 yds.
L.R. 100 yds
18" Tile Pipe
1080·00
V.C. 0·5%
Temporary Timber Trestle on Sills
350 ft. lg.
Concrete U Abutment on Piles
Steel Trestle 520 ft. lg.
60 & 30' Plate Girders
Masonry Pedestals
Vermilion River
150 ft. Steel Deck Truss
100 ft. Steel Thro. Truss
Concrete Piers & Abutment
ST. JOHN MON. & WESTN. RY.
LEVEL
Sand and Gravel Hard Bottom
Rock
H.W.L. 1046·30
L.W.L. 1032·80
B.M. 1054·30 Top N.E. Wing Wall of Culvert, St. J. M. & W. Ry.
Tunnel 250 ft. lg.
S.R. 3650 yds.
C.E. 1000 yds
H.E. 300
1300
1084·00
R.F. 3000 yds.
1080·00
Slope Wall
0·24
4'x4' Masonry Box
C.E. 400 yds
1086·01
0·4
1087·21
Grading commenced
0·24
1089·15
190
0·4
Extension of Siding
56 lbs. Moss Bay 1897 - 24" Angle Bars
TRACKLAYING
BALLAST
SURFACING
E.C. 4273+60 = 2296+10 Main Line Chainage
B.C. 4272+75
S. 41°52' W.
E.C. 4271+45
7°30' R. A. 6°22'
B.C. 4270+60
S. 35°30' W.
S. 35°30' W.
E.S. 4255+10
E.C. 4252+10
A. 4°30'
3° L.
A. 17°30'
B.C. 4246+80
B.S. 4243+80
A. 4°30'
S. 62°12' W.
E.S. 4214+170 = 4215+00
E.C. 4211+70
A. 15°48'
4° R.
B.C. 4210+00
A. 8°00'
A. 8°00'
B.S. 4200+00
E.S. 4205+00
S. 39°24' W.
A. 8°00'
4° L.
A. 9°36'
E.C. 4201+00
B.C. 4198+60
A. 8°00'
B.S. 4194+60
S. 65°00' W.
20
10
2300
4270
60
4250
40
30
20
10
4200
90
60 lbs. "Barrow" 1898 - 24" Angle Bars
73 lbs. Carnegie 1904 - 26" Angle Bars
72 lbs. Cammell 1905 - 44" Angle Bars
New Siding
TRACKLAYING
BALLAST
SURFACING
(For Progress Profiles only)
PROGRESS PROFILE COLOURS
Sepia JAN.
Indian Red FEB.
Neutral Tint MAR.
Burnt Sienna APR.
Emerald Green MAY.
Carmine JUNE.
Indian Ink JULY.
Chrome Yellow AUG.
Cobalt Blue SEPT.
Vermilion OCT.
Violet Carmine NOV.
Hookers Green DEC.
REFERENCE
Common Excavation C.E.
Hard Excavation H.E.
Solid Rock S.R.
Loose Rock L.R.
Rock Fill R.F.
Breaks in Elevation
Chainage
Elev. & Change

FORM M. W. 2202.

SIDE TRACK RECORD.

PROGRESS PROFILE.



from Black River
MAPLEWOOD
C. P. R. MAIN LINE
to South Bay
Mile 36 from South Bay
Heavy Growth Maple, Birch & Poplar
Cleared
Lt. Scrub
Cedar, Pine & Spruce
Under Cultivation
(For Location & Progress Profile) CLEARING (For Progress Profiles Only)
Double 4'x4' Cedar Culvert
B.M. 1096.25 Stone Post 4273+20
1095.20
C.E. 650 yds.
H.E. 300 yds
V.C. 0.1%
0.35
S.R. 6860 yds
L.R. 2940
C.E. 9800
19600
Highway Rideau to Spencerwood Del. Concesn V. & VI. Overhead Wooden Bridge
1095.00
Creek 7 ft. Concrete Arch
Creek Divert
B.M. 1088.22 Maple Stump 4240+50
18 Tile Pipe
C.E. 500 yds.
L.R. 100 yds
1080.00
V.C. 0.3%
Temporary Timber Trestle on Sills 350 ft. lg.
Concrete U Abutment on Piles
Steel Trestle 520 ft. lg. 60 & 30 Plate Girders Masonry Pedestals
Vermilion River
150 ft. Steel Deck Truss 100 ft. Steel Thro Truss } Concrete Piers & Abutment
ST. JOHN MON. & WESTN. RY
LEVEL
Sand and Gravel Hard Bottom
Rock
B.M. 1054.30 Top N.E. Wing Wall of Culvert, St. J. M. & W. Ry
H.W.L. 1046.30
L.W.L. 1032.80
Tunnel 250 ft. lg.
S.R. 3650 yds.
C.E. 1000 yds
H.E. 300
1300
1084.00
R.F. 3000 yds.
1080.00
Slope Wall
4' x 4' Masonry Box
C.E. 400 yds
1086.01
1087.21
1089.13
Grading commenced
MAIN LINE BASE OF RAIL
TRACK SUB-GRADE
1150
1100
1050
1000
Extension of Siding
56 lbs. Moss Bay 1897 - 24" Angle Bars
TRACKLAYING
BALLAST
SURFACING
S. 35°30' W.
E.C. 4273+60 = 2296+10 Main Line Chainage
B.C. 4272+75
S. 41°52' W.
E.C. 4271+45
7°30' R. A. 6°22'
B.C. 4270+60
S 35°30' W
E.S. 4255+10
E.C. 4252+10
A. 4°30'
3° L. A. 17°30'
B.C. 4246+80
A. 4°30'
B.S. 4243+80
S 62°12' W.
E.S. 4214+170 = 4215+00
A. 8°00'
E.C. 4211+70
B.C. 4210+00
A. 5°48' 4° R.
A. 8°00
B.S. 4200+00
E.S. 4205+00
S. 39°24' W.
A. 8°00'
E.C. 4201+00
4° L. A. 9°36'
B.C. 4198+60
A. 8°00'
B.S. 4194+60
S 65°00' W
20
10
2300
4270
60
4250
40
30
20
10
4200
90
60 lbs. "Barrow" 1898 - 24" Angle Bars
New Siding
73 lbs. Carnegie 1904 - 26" Angle Bars
72 lbs. Cammell 1905 - 44" Angle Bars
TRACKLAYING
BALLAST
SURFACING
(For Progress Profiles only)
PROGRESS PROFILE COLOURS
Sepia JAN.
Indian Red FEB.
Neutral Tint MAR.
Burnt Sienna APR.
Emerald Green MAY.
Carmine JUNE.
Indian Ink JULY.
Chrome Yellow AUG.
Cobalt Blue SEPT.
Vermilion OCT.
Violet Carmine NOV.
Hookers Green DEC.
REFERENCE
Common Excavation C.E.
Hard Excavation H.E.
Solid Rock S.R.
Loose Rock L.R.
Rock Fill R.F.
Breaks in Elevation
Chainage
Elev. & Chainage

Size, Approximately 12x24 inches, Tracing Paper.

Form M. W. 2202.

A. B. & C. R. R. Co.—Side Track Record

Side Tracks on ____________ Division ____________ Sub-Division ____________

Mile Post	Location			Township or School District	Name or Number of Track	Connected or Spur	A.F.E.	Contract	Date Completed	Character of Rail (Indicate Age, Weight and Kind)	Total June 30, 19				Changes During Year				Remarks
	Right or Left	Station	State and County				Number	Number			Ownership			Total	Ownership			Total	
											Railroad		Private		Railroad		Private		
											In Corp. Limits	In County			In Corp. Limits	In County			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Amount brought forward.																			
Amount carried forward.																			

To be Bound on This Edge.

Size 8x13 inches. Form M. W. 2100

*ESTIMATE FOR TRACK CONSTRUCTION.

A. B. & C. R. R. Co.

TRACK ESTIMATE .... DIVISION

Work ....

.... At ....

Date of Estimate .... 19 ....

Maximum Grade Away From Main Track ....%.

Total Length of Track in Ft ....

Maximum Grade in Direction of Main Track ....%

Total Clearance Length ....Ft

Made by ....

Maximum Curvature ....Degrees....................Min

.... (Title.)

Width of Roadbed on Fills ....Ft.. in Cuts....................Ft.

ITEM	DESCRIPTION	AMOUNT	UNIT PRICE	COST	CREDITS FOR OLD MATERIAL	Chargeable to
Waylands	Acres	Ac.				
Clearing	Squares (100 Ft. x 100 Ft.)	Sq.				
Moving Track		Ft.				
" Buildings						
" Fence	Kind	Rods				
Grubbing	Squares (100 ft. x 100 ft.)	Sq.				
Grading	Cu Yds of	Cu. Yds				
Pipes Kind	Size	Lin. Ft.				
Drain Tile "	"	" "				
Culverts "	"					
Bridges "		Lin. Ft.				
Ties "	(Class) Treated					
"	"					
Rail	Lbs per Yd.	Tons				
"	" " "	"				
"	" " "	"				
Angle Bars	Class Lb., Length	Pairs				
" "	" " "	"				
" "	" " "	"				
Bolts	Size	Kegs				
"	"	"				
Nut Locks Kind		Boxes				
Spikes		Kegs				
Rail Braces						
Tie Plates						
*Ballast (in Place)	QUARRY PIT	Cu. Yds,				
†Turnouts Complete						
" "						
Turnouts without Switch Ties						
" " " "						
Switch Ties	For No. Turnout	Sets				
" "	" " "	"				
Slip Switches	Wt Lb., No					
Derails Complete	Kind					
Railroad Crossings	Wt. Lb., Style					
Railroad Crossing Timbers		Ft. BM				
Cattle-Guards (state kind)		Sets				
Road Crossings		Ft. BM				
Signs (state kind)						
Fences (state kind)		Rods				
Wing Fences		Pairs				
Interlocking						
Telegraph and Telephone						
Signals						
Battery Wells						
Paving Kind		Sq. Yds				
Sewers "	Size					
Water Mains "	"					
Fire Hydrants "	No. of Nozzles					
Man Holes	Size					
Catch Basins	"					
Bumping Posts	Style					
Tunnels						
Labor (state character)						
" " "						
Handling Material						
Freight on "						
	TOTALS					
Eng'r and Supt						
	Estimated Gross Cost					
	Less Credits					
	NET ESTIMATED COST					
	The Expense is Chargeable to					
	Maintenance Account					
	Betterment					
	Additions "					

*State kind of Ballast and Quarry or Pit from which it is to be taken if possible.

†Use item, Turnouts Complete, in estimate for track to be paid for entirely by this Company

Drafting File Reference .... Letter File Reference ....

---

* Adopted, Vol. 10, 1909, pp. 865, 866, 869, 873, 874.

Size 8x13 inches. Form M. W. 2201

A. B. & C. R. R. CO.

Form for Estimates for { **Building** / **Bridge** / **Water Service** } **Construction**
(Face of Form)

Plan No. ________

Authority No. ________ Estimate No. ________

________ Division

Estimate of Cost of ________

Prepared ________ Date ________ By ________ Name ________

Estimate must be itemized under the various headings shown on back of sheet.

Items	Labor		Material						Total	
			Quantity		Unit Cost		Total			
Total										

Cost of Reproducing Abandoned Facilities ________

Distribution of Cost:
To Maintenance or Operation. ________
To Betterment. ________
To Outside Companies or Individuals. ________

---

* Adopted, Vol. 12, 1911.

Size 8x13 inches. Form M. W. 2201

Reverse Side of Form for Estimates for Bridges.

Items	Details
1. Additional Land.	Real Estate, Easements.
2. Foundation.	Excavation, Altering Existing Structure, Sheet Piling, Coffer Dam, Piling and Grillage, all expense to prepare for Footing.
3. Substructure	Masonry Footings, Pile Piers, Masonry Piers, Steel Piers.
4. Superstructure.	Steel Erection, Decking, Painting. Masonry Arches, Water Proofing, Reinforcing. Iron, Concrete and other types of Culvert Pipe.
5. Filling and Back Filling and Cleaning	
6 Train Service	
7 Engineering.	
8 Miscellaneous Expense	
Credits	

Size 8x13 inches. Form M. W. 2201

Reverse Side of Form for Estimate for Building Construction

Items	Details
1. Preparation of Site.	Grading, Removal of Buildings, etc
2. Foundation	Excavation and Foundation material in place.
3. Body Brick Steel Concrete Framework	All material in place comprising the frame work of the building except items listed separately
4. Platforms and Sidewalks.	All platforms either attached or built in connection with building Give separate estimates for each type, where more than one is to be used.
5. Driveways.	Give separate estimates for each type where more than one type is used.
6. Flooring.	Cost of materials above joists.
7. Plastering.	Including lathing
8. Painting and Decorating.	Interior and Exterior painting and glazing
9. Fire Protection	
10. Lighting.	
11. Hardware.	
12. Heating.	
13. Water Supply.	All expense of Water Supply outside of building proper
14. Plumbing.	
15. Sewerage.	All expense of Sewerage outside of building proper
16. Roofing.	All materials in place above Sheathing.
17. Guttering and Downspouts.	
18. Furniture.	
19. Scales.	
20. Elevators and Conveying Facilities.	
21. Miscellaneous Expense.	
Credits	Covering Salvage and to be itemized as above

Size 8x13 inches. Form M. W. 2201

Reverse Side of Form for Estimate for Water Service Construction.

Items	Details
1. Right-of-Way	Easement, Water Right.
2. Grading.	Clearing, Excavation Trenching, Back Filling
3. Fencing	
4. Telephone	Line, Instruments
5. Bridges and Structures	Dams, Wells, Tanks or Stand Pipes, Water Column Softeners, Filter Wind Mill, Track Pan, Power House. Outbuildings, Pumper's Dwelling, Pipe Lines
6. Machinery	Boilers, Engines, Motors, Pumps
7 Transportation	Men and Materials
8. Engineering	
9. Miscellaneous Expense	
Credits	

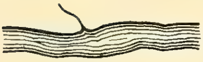
*CONVENTIONAL SIGNS.

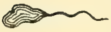
Standard Conventional Signs for use on right-of-way, topographical and other maps are desirable in railway work, and the Conventional Signs illustrated on forms M. W. 1903, 1904 and 1905 are recommended as good practice.

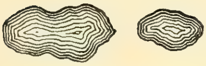
CONVENTIONAL SIGNS FOR USE ON TOPOGRAPHICAL AND RIGHT-OF-WAY AND TRACK MAPS.

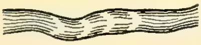
Form M. W. 1903.

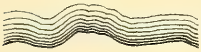
HYDROGRAPHY (*Shown in Blue*).

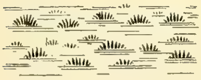

Streams.

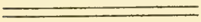

Springs and Sinks.

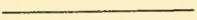

Lakes and Ponds.


Falls and Rapids.

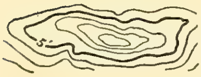

Water Line.

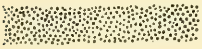

Marsh.

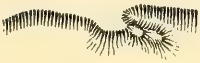

Canals.

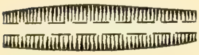

Ditches.

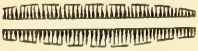
RELIEF (*Shown in Brown*).

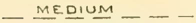

Contour System.


Sand.

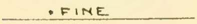

Cliffs.


Cuts.


Embankments.

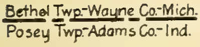
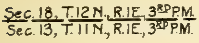
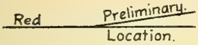
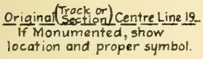
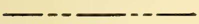
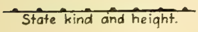
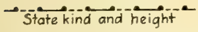
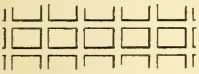
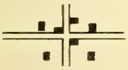
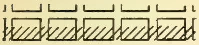
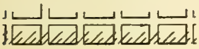


Bottom of Slope.

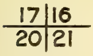
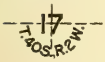
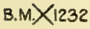


Top of Slope.

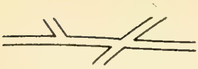
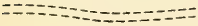
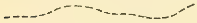
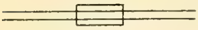
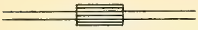
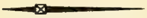
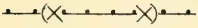
BOUNDARY AND SURVEY LINES (*Civil*).

 Bethel Twp-Wayne Co-Mich. Posey Twp-Adams Co-Ind.	Political Divisions; State, County or Township Line.
 Sec. 18, T. 12 N., R. 1 E., 3RD P.M. Sec. 13, T. 11 N., R. 1 E., 3RD P.M.	Government Surveys; Base, Meridian, Township, Section or Harbor Line.
————————	Street, Block or other property line.
 Red Preliminary. Location.	Survey Lines.
 Original (Track or Section) Centre Line 19 If Monumented, show location and proper symbol.	Center Lines.
	Company Property Line.
 State kind and height.	Fence (on street line).
 State kind and height	Fence (on Company property Line).
	Cities.
	Villages.
	City Limits.
	Fire Limits.

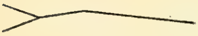
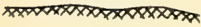
SECTION CORNERS, MONUMENTS, ETC.

	Section Corner.
	Section Center.
	Triangulation Station or Transit Point.
	Bench Mark.
□	Stone Monument.
■	Iron Monument.

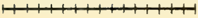
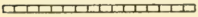
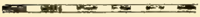
HIGHWAYS AND CROSSINGS.

	Public and Main Roads.
	Private and Secondary Roads.
	Trails.
	Road Crossings.
	Cattle-Guard.
	Crossing Gate.
	Turnstile.

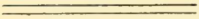
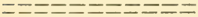
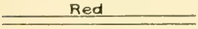
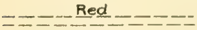
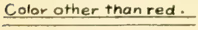
MINES.

	Tunnel.
	Shaft.
	Test Opening.
	Coal Outcrop.
	Mine in Operation.

RAILWAYS (*Topographical Maps*).

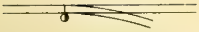
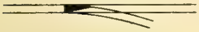
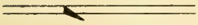
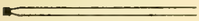
	Steam.
	Electric.
	Street Railways.

RAILWAY TRACKS (*Track Maps*).

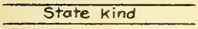
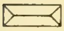
	Old Track to remain.
	Old Track to be moved.
	New Tracks.
	Future Tracks.
	Foreign Tracks.

For tracks and yard studies and on smaller scale maps than 100 ft. to 1 in. use single lines instead of double lines.

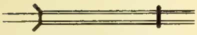
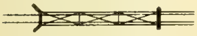
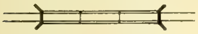
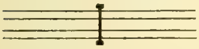
TRACK FIXTURES.

	Turnout and Switch Stand.
	Interlocked Switch.
	Derail.
	Bumping Post.

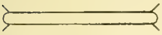
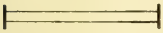
BUILDINGS.

	Use letters to indicate kind:
	F—frame.
	B—brick.
	S—stone.
	C—concrete.
	Cor. I—corrugated iron.
	Platform or Driveway.
	Turntable.
	Interlocking Tower.
	Battery Box.

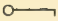
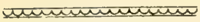
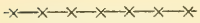
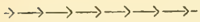
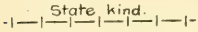
BRIDGES.

	Girder.
	Truss.
	Trestle.
	Signal Bridge.

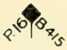
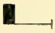
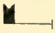
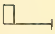
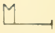
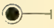
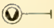
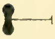
CULVERTS, SEWERS, ETC.

	Masonry Arch or Flat Top Culvert.
	Pipe or Wood Box Culverts or Drains; state kind and length, and kind of walls, if any.
	Catch Basin.
	Manhole.
	Sump.

WATER SUPPLY AND PIPE LINES.

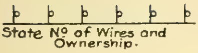
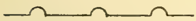
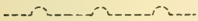
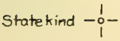
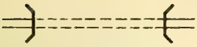
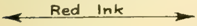
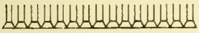
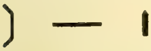
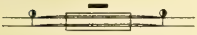
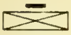
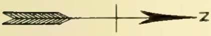
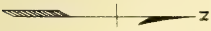
	Water Tank.
	Water Column.
	Track Pan.
	Company Water Pipe.
	Other Water Pipe.
	Steam, Compressed Air or Gas.
	Fire Hydrant.
	Valve.
	Riser.
	Meter.

SIGNS AND SIGNALS.

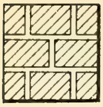
	Mile Post.
	Section Post.
	Yard Limits.
	Automatic Bell.
	Home Interlocking Signal.
	Distant Interlocking Signal.
	Home Automatic Signal.
	Distant Automatic Signal.
	Home Disc Signal.
	Distant Disc Signal.
	Train-Order Signal.

Note.—The foot of the mast shows the exact location of the signal.

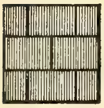
MISCELLANEOUS.

 State N° of Wires and Ownership.	Pole Wire Lines.
	Switch or Signal Connecting Lines.
	Wire Conduit.
	Arc Lamp.
	Other Lamps.
	Railway Tunnel.
	Dimension Line.
	Cribbing.
	Abutment, Wall and Pier.
	Track Scales.
	Wagon Scales.
	Mail Crane.
	True Meridian.
	Magnetic Meridian.

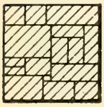
MASONRY.



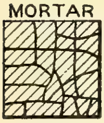
Rockfaced Ashlar.



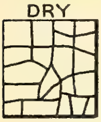
Dressed Ashlar.



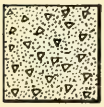
Uncoursed Ashlar.



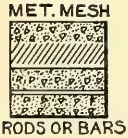
Rubble.



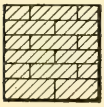
Rubble.



Plain Concrete.

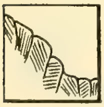

MET. MESH
RODS OR BARS

Reinforced Concrete.

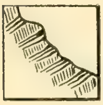


Brick.

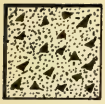
GEOLOGICAL STRATA.

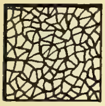


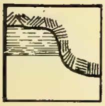
Solid Rock.

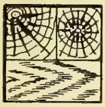


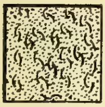
Seamy Rock.

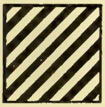

Cinders.

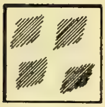

Crushed Rock.

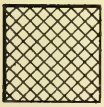

Water.

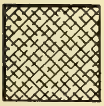

Wood.

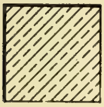

Wool, Felt, Asbestos, Leather, etc.

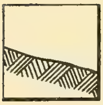

Mica, Rubber, Vulcanite, Fiber, etc.


Glass.

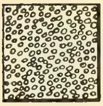

Comp. Metal, Lead, Babbitt, etc.


Bronze.

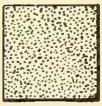

Brass.



Earth.

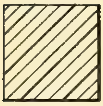


Gravel.

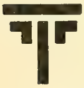


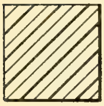
Sand.

METALS.

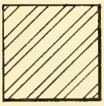


Wrought Steel.

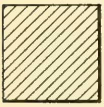




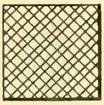
Cast Steel.



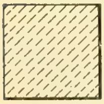
Wrought Iron.



Cast Iron.

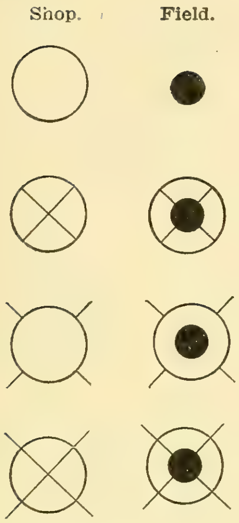


Malleable Iron.



Copper.

A—BRIDGE RIVETS.

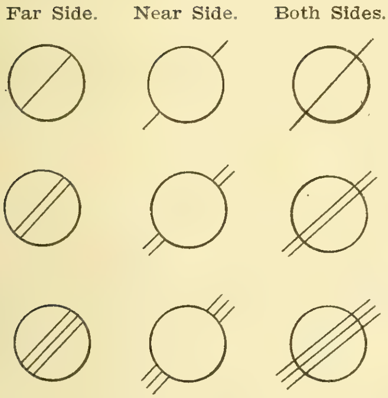


Two Full Heads.

Countersunk and chipped, far side.

Countersunk and chipped, near side.

Countersunk and chipped, both sides.


Far Side.
Near Side.
Both Sides.

Countersunk and not chipped.

Flattened to ¼-in. high for ½-in. and ⅝-in. rivets.

Flattened to ⅜-in. high for ¾-in., ⅞-in. and 1-in. rivets.

B—STRESSES.

+ Tension.

— Compression.

COMMITTEE XII.

RULES AND ORGANIZATION.

*GENERAL RULES FOR THE GOVERNMENT OF EMPLOYES OF THE MAINTENANCE OF WAY DEPARTMENT.

GENERAL NOTICE.

(1) To enter or remain in the service is an assurance of willingness to obey the rules.

(2) The service demands the faithful, intelligent and courteous discharge of duty.

(3) Obedience to the rules is essential to the safety of passengers and employes, and to the protection of property.

(4) Employes must exercise care and watchfulness to prevent injury to themselves, other employes and the public, and to prevent damage to property. In case of doubt they must take the safe course. They must know that all tools and appliances are in safe condition before using. They must move away from tracks upon approach and during passage of trains, and, so far as practicable, prevent the public from walking on tracks or otherwise trespassing on the right-of-way.

(5) Employes must do all in their power to prevent accidents, even though in so doing they occasionally perform the duties of others.

(6) Co-operation is required between all employes whose work or duties may be jointly affected.

(7) Anything that interferes with the safe passage of trains at full speed is an obstruction.

(8) Employes in accepting employment assume its risks.

(9) To obtain promotion, capacity must be shown for greater responsibility.

(10) Employes must not absent themselves from duty, exchange duties with others or engage substitutes.

(11) Employes must conduct themselves properly at all times. They will be courteous to fellow-employes and patrons of the road.

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* Adopted, Vol. 7, 1906, pp. 20, 21, 26; Vol. 8, 1907, pp. 24-39; Vol. 9, 1908, pp. 29, 30, 31-38; Vol. 10, 1909, pp. 51-55, 56-69; Vol. 12, Part, 1, 1911.

ORGANIZATION.

(1) The Maintenance of Way Department on each division is in charge of the ....(Title)................, who will report to and receive instructions from the ....(Title)................

(2) The work of the Department will be subdivided under the following heads:

Track Supervisors.
Supervisors of Structures.
Signal Supervisors.

RULES GOVERNING TRACK SUPERVISORS.

(1) Track Supervisors shall report to and receive instructions from the ....(Title)................

(2) They shall be responsible for the safe condition and proper maintenance of track, roadway, right-of-way, station grounds and driveways, and must inform themselves of the condition of structures. They must make temporary repairs of such defects as may endanger or delay the movement of trains, and promptly report defective conditions to the ....(Title)................

(3) They must make frequent inspections of track, roadway, right-of-way, station grounds and driveways, and have necessary repairs made as promptly as conditions require.

(4) They shall, as necessary, employ men for carrying out the duties for which they are responsible.

(5) They must know that foremen are familiar with the operating rules in regard to train signals and flagging, and that they fully understand and comply with them.

(6) They must, in case of obstruction or damage to track or roadbed, proceed to the place with the forces at their command and do all in their power to promptly clear and repair the track.

(7) They shall investigate and report on Form No. .... accidents which may be attributable to defects in, or result in damage to, track, roadbed or structures.

(8) They shall conform to the prescribed standards and plans in the execution of work under their charge.

(9) They must know that foremen are supplied with tools and materials necessary for the efficient performance of their duties, and see that these are properly used and cared for.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed in their districts by contractors, or others who do not come under their charge, and see that nothing is done by them that will interfere with the safety of track or the movement of trains.

(12) They shall have immediate supervision of work train service for the maintenance of track and employ such service only when authorized by the ....(Title)..............................

(13) They must know that foremen are provided with the rules, circulars, forms and special instructions pertaining to their duties, and that they fully understand and comply with them.

(14) They shall see that the vicinity of all bridges and trestles is clear of all combustible matter, and that bridge seats, tops of piers and other readily accessible portions of bridges and trestles are clear of cinders and dirt and that water barrels are full of water.

(15) They shall see that waterways and the approaches and outlets thereto are free from obstructions.

(16) They shall see that no encroachment upon, or occupancy of any portion of the Company's buildings, right-of-way or station grounds is permitted, except by proper authority.

RULES GOVERNING TRACK FOREMEN.

(1) Track Foremen shall report to and receive instructions from the ....(Title)..............................

(2) Unless otherwise directed, they shall be responsible for the proper inspection and safe condition of the track and roadway under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

(3) They must go over their sections, or send a reliable man, with suitable tools, at least once a day to make a thorough inspection, to see that the track, highway crossings, signals, culverts, bridges, fences, telegraph lines, etc., are in safe condition.

(4) They shall employ men as the ....(Title).............. directs. They must treat employes with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men

without cause. They must keep the required records of the time of their men and of the materials used.

(5) They must each have a copy of the current time-table, and be thoroughly familiar with the rules and regulations therein, and with the time of trains over their sections. They must carefully observe signals displayed by all trains, and assure themselves before obstructing track that all trains and sections due have passed. No notice will be given of extra trains, and employes must protect themselves as prescribed by the Rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employes who are required to have the standard time.

(6) If, in the judgment of the Track Foreman, the track or any bridge or culvert is not safe, he must at once put out the proper signals to warn approaching trains, notify the proper officers of its condition, and do all in his power to make necessary repairs.

(7) Track Foremen must, in case of accident, promptly render all assistance in their power, whether the accident occurs on their own or adjacent sections. They shall investigate and report on Form No. ...... all accidents occurring on their sections, which may be attributable to, or result in damage to, track, roadbed or structures.

(8) They shall conform to the prescribed standards and plans in the execution of work under their charge.

(9) They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties, and shall make requisition to the ....(Title)...................... from time to time as additional supply becomes necessary.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed on their sections by contractors, or others who do not come under their charge, and see that nothing is done by them that will interfere with the safety of the track or the movement of trains.

(12) They must limit the use of handcars to the service of the Company, and must not, except by proper authority, permit anyone except employes of the Company, engaged in the performance of duty, to ride thereon. They must not permit, except by proper authority, the running of hand or velocipede cars belonging to private parties over the tracks of the Company.

(13) During heavy storms, whether by day or night, whereby the track or any portion of the Company's property becomes liable to damage, foremen and trackmen must be on duty; and at such times they must go over their sections to make sure that the track is safe, taking danger signals with them.

(14) They must keep the vicinity of all buildings, bridges and trestles cleared of all combustible matter, such as chips, bark, dry grass, etc.. They must keep bridge seats, tops of piers, and all other readily accessible portions of bridges and trestles cleaned of cinders and dirt. Where water barrels are furnished, they must keep them filled with water.

(15) They must keep a careful lookout for fires along the track, and prevent, if possible, the destruction of fences, wood or other material, and the spread of fires into adjoining fields. They must not permit fires to be started unless they have sufficient force to keep them under control.

(16) They must use constant care to see that waterways and the approaches and outlets thereto are kept free from brush, driftwood and other obstructions.

(17) They must not permit encroachment upon, or occupancy of, any portion of the Company's buildings, right-of-way, or station grounds, except by proper authority.

RULES GOVERNING SUPERVISORS OF STRUCTURES.

(1) Supervisors of Structures shall report to and receive instructions from the ....(Title)..................

(2) They shall be responsible for the safe condition and proper maintenance of structures. They must make temporary repairs of such defects as may endanger or delay the movement of trains, and promptly report defective conditions to the ....(Title).....................

(3) They must make frequent inspections of structures and have necessary repairs made as promptly as conditions require.

(4) They shall, as necessary, employ men for carrying out the duties for which they are responsible.

(5) They must know that foremen are familiar with the operating rules in regard to train signals and flagging, and that they fully understand and comply with them.

(6) They must, in case of damage to structures, promptly assemble forces, tools and materials and make necessary repairs.

(7) They shall investigate damage to structures resulting from train

accidents or other causes and make prompt report to the .....(Title).....

(8) They shall conform to the prescribed standards and plans in the execution of work under their charge.

(9) They must know that foremen are supplied with tools and materials necessary for the efficient performance of their duties, and see that these are properly used and cared for.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed on bridges and structures in their districts by contractors, or others who do not come under their charge, see that nothing is done by them that will interfere with the safety of structures, and report promptly to the ....(Title).................. if the work is not done in accordance with the prescribed standards.

(12) They shall have immediate supervision of work-train service for the maintenance of structures, and employ such service only when authorized by the ....(Title)..........................

(13) They must know that foremen are provided with the rules, circulars, forms and special instructions pertaining to their duties, and that they fully understand and comply with them.

(14) They shall see that water barrel rests at all timber bridges and trestles are in repair and supplied with barrels and buckets, and that station and other structures are equipped with the necessary water barrels, buckets and other appliances.

(15) They shall, in period of flood, observe and record the flow of water of the various streams passing under the track, and report to the proper officer any case in which the opening seems insufficient.

RULES GOVERNING BRIDGE AND BUILDING FOREMEN.

(1) Bridge and Building Foremen shall report to and receive instructions from the ....(Title)..........................

(2) They shall be responsibe for the proper inspection and safe condition of the structures under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

(3) They must make such inspections of the structures in their district as the ....(Title).................. may direct, and report their condition on Form No. ......

(4) They shall employ men as the ....(Title).................. directs. They must treat employes with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used.

(5) They must each have a copy of the current time-table, and be thoroughly familiar with the rules and regulations therein, and with the time of trains over their districts. They must carefully observe signals displayed by all trains, and assure themselves, before obstructing track, that all trains and sections due have passed. No notice will be given of extra trains, and employes must protect themselves as prescribed by the Rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employes who are required to have the standard time.

(6) They must, in case of damage to structures in their districts, promptly proceed to the place with the men, tools and materials at their command, and do all in their power to make necessary repairs.

(7) They must, in case of accident coming under their observation, report the facts to the ....(Title)..............................

(8) They shall conform to the prescribed standards and plans in the execution of work under their charge.

(9) They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties, and shall make requisition to the ....(Title).......................... from time to time, as additional supply becomes necessary.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

RULES GOVERNING SIGNAL SUPERVISORS.

(1) Signal Supervisors shall report to and receive instructions from the ....(Title)..............................

(2) They shall be responsible for the safe condition and proper maintenance of signals and interlocking plants. They must make temporary repairs of such defects as may endanger or delay the movement of trains, and promptly report defective conditions to the ...(Title).....

(3) They must make frequent inspections of signals and interlocking plants and have necessary repairs made as promptly as conditions require.

They must see that all failures of signals and interlocking plants are promptly investigated and report made on Form No. ......

(4) They shall, as necessary, employ men for carrying out the duties for which they are responsible.

(5) They must know that foremen are familiar with the operating rules in regard to train signals and flagging, and that they fully understand and comply with them.

(6) They must, in case of damage to signals or interlocking, promptly assemble forces, tools and materials, and make necessary repairs.

(7) They shall investigate and report on accidents which may be attributable to defects in, or result in damage to, the signal apparatus.

(8) They shall conform to the prescribed standards and plans in the execution of work under their charge.

(9) They must know that foremen are supplied with tools and materials necessary for the efficient performance of their duties, and see that these are properly used and cared for.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They shall keep themselves informed in regard to all work performed in their districts by contractors, or others who do not come under their charge, see that nothing is done by them that will interfere with the safe operation of signals, and report promptly to the .... (Title) .... if the work is not done in accordance with the prescribed standards.

(12) They shall have immediate supervision of work-train service for the maintenance of signals and interlocking plants in their districts, and employ such service only when authorized by the .... (Title) ....

(13) They must know that foremen are provided with the rules, circulars, forms and special instructions pertaining to their duties, and that they fully understand and comply with them.

RULES GOVERNING SIGNAL FOREMEN.

(1) Signal Foremen shall report to and receive instructions from the .... (Title) ....

(2) They shall be responsible for the proper inspection and safe condition of signals and interlocking plants under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

(3) They must make such inspections of the signals and interlocking plants in their districts as the ....(Title)............ may direct, and report all defects found on Form No. .....

(4) They shall employ men as the ....(Title)................ directs. They must treat employes with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used.

(5) They must each have a copy of the current time-table, and be thoroughly familiar with the rules and regulations therein, and with the time of trains over their districts. They must carefully observe signals displayed by all trains, and assure themselves, before obstructing track, that all trains and sections due have passed. No notice will be given of extra trains, and employes must protect themselves as prescribed by the Rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employes who are required to have the standard time.

(6) They must, in case of damage to signal or interlocking apparatus in their districts, promptly proceed to the place with the men, tools and materials at their command and do all in their power to make necessary repairs.

(7) They shall investigate and report on accidents which may be attributable to defects in, or result in damage to, the signal apparatus.

(8) They shall conform to the prescribed standards and plans in the execution of work under their charge.

(9) They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties, and shall make requisition to the ....(Title).......... from time to time as additional supply becomes necessary.

(10) They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.

(11) They must not make nor permit any permanent rearrangement or change in the signals or interlocking plants without proper authority.

COMMITTEE XIII.

WATER SERVICE.

*QUALITY OF WATER, METHODS OF TREATMENT AND RESULTS OBTAINED THEREFROM.

(1) In locating water stations along a railway, an investigation should be made of all the available water supplies, and care should be taken to avoid the use of poor water, or to curtail its use as much as possible.

(2) Most water used in locomotive boilers contains scale-forming matter in solution or suspension, causing trouble and expense in operating and maintaining locomotives.

(3) Hard water can be softened before it is put into locomotive boilers by treating it with chemicals.

(4) The hardness of water due to carbonates of lime and magnesia can be removed at a moderate expense for chemicals by the use of lime alone, without adding any soluble salts to the softened water.

(5) The hardness of water due to sulphates of lime and magnesia can be removed by the use of soda ash, a more expensive chemical. The chemical reaction removes sulphates of lime and magnesia, and leaves soluble sulphates of soda, which increase the tendency to foam.

(6) The removal of sulphates of lime and magnesia is of greater value than the removal of the carbonates alone, as the carbonates of lime and magnesia, without the presence of the sulphates of lime or magnesia, do not form hard scale, but are precipitated in the boiler as soft scale and mud.

(7) The mechanical methods of modern water-softeners are new and differ widely, but consist of two general types, the continuous and the intermittent.

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* Adopted, Vol. 9, 1908, pp. 110-112, 154; Vol. 11, Part 2, 1910, pp. 1143, 1144, 1219.

(8) At stations where hard water is used, special study should be made relative to the economical value of treating the water, and the method best adapted to meet the conditions.

(9) The cost of installing a water-softening plant varies according to the capacity of the plant, its type, cost of material and labor in the particular locality, and other local conditions.

(10) The cost of operating a water-softening plant varies according to the efficiency of the water-softening apparatus and the cost of lime and soda ash, or other chemicals available for softening water in the particular locality.

(11) The cost of chemicals required to soften water varies according to the quantity of hardening matter in the water, and also its composition.

(12) The benefits derived from water-softening plants are: Fewer boiler failures due to leaking; longer life of flues and firebox sheets; reduced cost of labor for repairing and washing boilers; increased locomotive mileage between shoppings; decreased number of locomotives required to perform the same service; less expense in cost of overtime and delays; saving in fuel.

(13) The greatest disadvantage in treating water is the increased tendency to foam, due to the reaction of soda ash on the sulphates of lime and magnesia.

*EFFICIENCY OF WATER SOFTENERS.

The greatest efficiency in the operation of a water-softening plant is produced by observing the following conditions:

(1) The solutions containing the reagent should be properly prepared.

(2) The reagents should be as near chemically pure as practicable.

(3) The mechanical device for introducing reagents should be such as to insure as near as possible a quantity of reagent in direct proportion to the flow of the untreated water.

(4) Where the lime and soda ash treatment is used, the volume of space for reaction and precipitation should be at least from three to four times the hourly capacity of the softener, depending on temperature and analysis of the water.

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* Adopted, Vol. 8, 1907, pp. 604-607, 615, 617, 620.

The equations for determining this space for both types of softeners, and Table 1, given below, conform to good practice.

In a continuous softener, the volume of the chambers through which the water passes, between the top of the portion reserved for sludge and the outlet through which the water finally flows to the storage tank, should be at least three times the hourly capacity of the plant, and where the temperature of the water is low, it should be four times the hourly capacity.

The determination of the number and volume of settling tanks for intermittent softeners depends on the number of pumps or batteries of pumps, necessary to handle the water; time required to fill or empty each settling tank, above the sludge line, and time necessary for reaction and precipitation.

Where gravity flow, both to and from the softener, cannot be obtained, pumps should be provided with intermittent plants, as follows:

One pump only is necessary:

(a) Where water is pumped to settling tanks and is transferred by gravity to storage tanks.

(b) Where water flows by gravity to settling tanks, and is transferred to storage tank by pumping.

(c) Where water is pumped to both the settling and storage tanks and the source of supply is ample to furnish double the capacity of the softening plant.

Two pumps are necessary:

(d) Where deep well pumps furnish supply and water must be pumped from settling tanks to storage tanks.

(e) Where water is handled by pumping to both settling and storage tanks, but the source of supply is not ample to furnish at least double the capacity of the plant.

In all of the cases where pumps are needed, excepting case "c," the capacity of each pump, or battery of pumps, used for each operation should at least be equal to the treating capacity of the softener. If the pumps used to transfer the treated water are of a larger capacity, so that water can be transferred to storage tanks in less time than is required to fill the settling tanks, less settling tank capacity will be required.

In case "c," as the pump must handle the water twice in its transfer from the source of supply through the softener and into the storage tank, its capacity should at least be equal to double the capacity of the softener, and the supply should be sufficient for the pump.

At least three feet of the bottom of each settling tank should be reserved for the accumulation of the precipitates; therefore, in estimating the settling space needed and the capacity of settling tanks, the settling space should be considered as lying entirely above this reserved portion.

With these points in view, the proper capacity for settling tanks, measured above the space reserved for sludge, can be determined as follows:

$a =$ capacity of softener in gallons per hour.
$b =$ hours required for reaction and precipitation.
$c =$ number of settling tanks (never less than 2).
$x =$ number of hours required to fill the portion of settling tank above the "sludge" portion.
$y =$ number of hours required to transfer treated water from one settling tank to the storage tank. (y should never be greater than x.)

In case "c," where one pump alternates between filling and emptying settling tanks, the time for filling and emptying the total number of tanks less one must equal the time for reaction and precipitation in that one, and x would equal y. As the capacity of the pump must be double the capacity of treating plant, the settling capacity in each tank would be $2ax$.

The equations expressing the above are:

$$2x\,(c-1) = b$$

$$x = \frac{b}{2c-2}$$

$$\text{Settling capacity each tank} = 2ax = \frac{2ab}{2c-2} = \frac{ab}{c-1}.$$

For plants where the quantity of water supplied to the softener and the capacity of the plant are equal, the settling capacity of each tank is equal to ax. The total number of hours required to fill all the settling tanks should equal the number of hours required to fill, precipitate and empty one tank, as expressed by the following equation:

$$
\begin{aligned}
c\,x &= x + b + y \\
x\,(c - 1) &= b + y \\
x &= \frac{b + y}{c - 1}
\end{aligned}
$$

If $y = x$, then $x = \dfrac{b}{c - 2}$; and $a\,x = \dfrac{a\,b}{c - 2}$.

If $y = \frac{1}{2}x$, then $x = \dfrac{b}{c - 1.5}$; and $a\,x = \dfrac{a\,b}{c - 1.5}$.

TABLE 1.

PROPER SETTLING CAPACITY OF TANKS ABOVE THE PORTION RESERVED FOR SLUDGE, UNDER VARIOUS CONDITIONS OF OPERATION IN INTERMITTENT WATER SOFTENERS.

Number of Tanks. "c"	Time required, Each Tank.			Settling Capacity of Tanks per 1000 Gallons, Capacity of Softener.	
	Filling. "x"	Reaction. "b"	Emptying. "y"	Each Tank.	Total.
When flow of water to softener is double the capacity of softener.					
2	2 Hours	4 Hours	2 Hours	4,000 Gals.	8,000 Gals.
3	1 "	4 "	1 "	2,000 "	6,000 "
4	⅔ "	4 "	⅔ "	1,333 "	5,333 "
2	1½ "	3 "	1½ "	3,000 "	6,000 "
3	¾ "	3 "	¾ "	1,500 "	4,500 "
4	½ "	3 "	½ "	1,000 "	4,000 "
When flow of water to softener equals the capacity of softener.					
3	4 Hours	4 Hours	4 Hours	4,000 Gals.	12,000 Gals.
4	2 "	4 "	2 "	2,000 "	8,000 "
5	1⅓ "	4 "	1⅓ "	1,333 "	6,667 "
6	1 "	4 "	1 "	1,000 "	6,000 "
2	8 "	4 "	4 "	8,000 "	16,000 "
3	2⅔ "	4 "	1⅓ "	2,667 "	8,000 "
4	1⅗ "	4 "	⅘ "	1,600 "	6,400 "
5	1⅐ "	4 "	4⁄7 "	1,143 "	5,714 "
3	3 "	3 "	3 "	3,000 "	9,000 "
4	1½ "	3 "	1½ "	1,500 "	6,000 "
5	1 "	3 "	1 "	1,000 "	5,000 "
2	6 "	3 "	3 "	6,000 "	12,000 "
3	2 "	3 "	1 "	2,000 "	6,000 "
4	1⅕ "	3 "	⅗ "	1,200 "	4,800 "
5	6⁄7 "	3 "	6⁄7 "	857 "	4,286 "

Table 1 is developed from these equations and gives the proper settling capacity per 1000 gallons per hour capacity of treating plant under various conditions and varying number of settling tanks. From this table it will be noted that with the same time allowed for reaction and precipitation, the least number and the smallest capacity of settling tanks is required where the flow of the untreated water to the softener is double the hourly capacity of the softener, and the one pump works alternately filling and emptying these tanks. Where pumping is a necessity and sufficient supply can be obtained, the one-pump plan will be the most economical in maintenance and operation of the intermittent plants.

*RELATIVE ECONOMY OF DIFFERENT TYPES OF SOFTENERS.

The relative economy of the different types of water softeners can be determined by comparing the total annual cost of each, exclusive of the cost of chemicals. This annual cost should be composed of:

(a) Interest on the sum of the cost of installation and value of ground space occupied.
(b) Depreciation;
(c) Current running repairs;
(d) Additional labor and fuel required above the ordinary cost of operating the water station.

†REAGENTS USED IN WATER-SOFTENING.

The quantity of reagents required per unit of scaling or corroding substance held in solution, given in Table 2, is recommended as good practice.

Where the commercial product is not chemically pure, the proportion of reagents should be increased to correspond with an equivalent quantity of pure reagent.

Given the analysis of a water, the pounds of incrusting or corrosive matter held in solution per 1000 gallons can be obtained by dividing the grains per gallon of each substance by seven, or the parts per 100,000 by twelve.

By using Table 2, the quantity of reagents per 1000 gallons can be readily calculated, and by applying local cost of the same, the cost for chemicals per 1000 gallons will be obtained. In order to ascertain the full amount of lime necessary, the amount of free carbonic acid contained in the water should be determined, as well as the solids contained in solution, since this free acid must be eliminated in order to obtain efficient treatment of water and reduce scaling matter to the minimum.

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* Adopted, Vol. 8, 1907, pp. 615, 620.
† Adopted, Vol. 8, 1907, pp. 608-610, 615, 621.

TABLE 2.

QUANTITY OF PURE REAGENTS REQUIRED TO REMOVE ONE POUND OF INCRUSTING OR CORROSIVE MATTER FROM THE WATER.

Incrusting or Corrosive Substance Held in Solution.	Amount of Reagent (Pure)	Foaming Matter Increased.
Sulphuric acid	0.57-lb. lime plus 1.08 lbs. soda ash	1.45 lbs.
Free carbonic acid	1.27 lbs. lime	None
Calcium carbonate	0.56-lb. lime	None
Calcium sulphate	0.78-lb. soda ash	1.04 lbs.
Calcium chloride	0.96-lb. soda ash	1.05 lbs.
Calcium nitrate	0.65-lb. soda ash	1.04 lbs.
Magnesium carbonate	1.33 lbs. lime	None
Magnesium sulphate	0.47-lb. lime plus 0.88 lb. soda ash	1.18 lbs.
Magnesium chloride	0.59-lb. lime plus 1.11 lbs. soda ash	1.22 lbs.
Magnesium nitrate	0.38-lb. lime plus 0.72 lb. soda ash	1.15 lbs.
Calcium carbonate	3.15 lbs. barium hydrate	None
Magnesium carbonate	3.76 lbs. barium hydrate	None
Magnesium sulphate	2.62 lbs. barium hydrate	None
*Calcium sulphate	2.32 lbs. barium hydrate	None

*In precipitating the calcium sulphate, there would also be precipitated 0.74-lb. of calcium carbonate or 0.31-lb. of magnesium carbonate, the 2.32-lbs. of barium hydrate performing the work of 0.41-lb. of lime and 0.78-lb. of soda ash, or for reacting on either magnesium or calcium sulphate, 1-lb. of barium hydrate performs the work of 0.18-lb. of lime plus 0.34-lb. of soda ash, and the lime treatment can be correspondingly reduced.

*FOAMING OR PRIMING.

Water having foaming matter in solution requires changing as the concentration of foaming solids in locomotive boilers reaches the critical point, i. e., about 100 grains per gallon.

The grains per gallon of foaming matter in solution represent the minimum per cent. of water wasted in locomotive boilers by blowing off and changing of waters.

Treatment by soda ash increases foaming matter in solution, with a corresponding per cent. increase in water wasted equivalent to at least the grains increase of foaming matter per gallon.

For each pound additional foaming matter per 1000 gallons of water, the increased expense would be equal to the cost of pumping and treating at least 70 gallons of water, and the fuel for heating the same to the temperature of boiler water.

†MINIMUM QUANTITY OF SCALING AND CORROSIVE MATTER WHICH WILL JUSTIFY TREATMENT.

The minimum quantity of solids in solution that will justify treatment depends on local conditions and the composition of the solids. By

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* Adopted, Vol. 8, 1907, pp. 615, 616, 621.
† Adopted, Vol. 8, 1907, pp. 612, 613, 616, 622.

applying the proper local values to the equation given below, this quantity can be determined.

The following equation gives the point where the benefits derived from treating the water will balance the cost of treating:

$X =$ Number cwt. (100 lbs.) solids removed from water per annum.

$B =$ Money value of benefits obtained from removing 100 lbs. solids; this will include:

Saving in boiler washing and repairs;

Saving in fuel.

Increased service obtained from locomotives, represented by the interest on the cost of the additional number of locomotives that would be required to perform the service rendered by locomotives using the soft water, if based on the performance prior to treating the water.

$C =$ Cost per 100 lbs. of solids removed to operate the plant, as follows:

Additional cost of labor;

Additional cost of fuel or power;

Cost of chemicals;

Cost of current repairs.

$D =$ Cost of plant installed.

$I =$ Interest per annum on D.

$L =$ Estimated useful life of plant in years.

$R =$ Estimated value of materials recovered from plant after L years.

$S =$ Annual depreciation of plant, equivalent to a sum per year, which, if placed in a sinking fund at I rate of interest, would amount to $D—R$ in L years. (See table, page 16, Kent's Pocket Book.)

The benefits would balance the cost when $XB = XC + I + S$. (1)

$$X = \frac{I + S}{B - C} \qquad (2)$$

The number of pounds solids removed daily to make benefits equal the cost would be $\dfrac{I + S}{3.65\ (B - C)}$ (3)

If more than this amount of solids is removed the plant will be economical.

Values for *B* can only be fixed for each particular case, as some of the matter held in solution is more injurious than the same weight of other matter.

*GENERAL PRINCIPLES OF WATER SUPPLY SERVICE.

SUPPLY—QUANTITY.

The supply (if possible within economical limits) should be sufficient so that the total amount of water likely to be required during the average volume of business in twenty-four hours can be drawn from the source in seven hours at terminal stations and in four hours at intermediate stations.

SUPPLY—SOURCE.

Where water of suitable quality and in sufficient quantity can be purchased at reasonable figures, it is recommended above all other sources.

Springs should be carefully gaged for a period of at least one year, and the possibility of future pollution and increased demands for supply therefrom carefully considered before adoption as a permanent source. A reservoir should be constructed at the spring where conditions permit.

Lakes, natural ponds, creeks or rivers require special investigation in each case. The points to be considered are quantity, quality—as regards chemical impurities and amount of sediment carried—future pollution and riparian rights. The style of intake will depend on local conditions entirely; no definite rule can be given.

Dug well construction should always be preceded by a careful auger test to determine the strata to be encountered. Size and construction depend on the strata to be passed through; no definite rule can be given.

Surface pipe wells are satisfactory where local conditions permit of their use. This system is one which can be extended to collect a large volume of ground water. The recommended layout is shown on Fig. 1.

Artesian deep wells, where obtainable, are a satisfactory source; however, their flow is liable to constant decrease and finally cease.

Deep wells requiring pumping are recommended only as a last resort. The recommended form for record is shown on M. W. 1304.

A chemical analysis should be made of all water, and the question of cost of treatment, if required, thoroughly investigated, as outlined under the heading "Minimum Quantity of Scaling and Corrosive Matter which will justify Treatment."

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* Adopted, Vol. 10, Part 1, 1909, pp. 735-765, 810-814.

PUMPING PLANTS.

The size of the plant should be in accordance with the following table:

Quantity per 24 Hours, in Gallons.	Terminal Stations.		Intermediate Stations.	
	Time Pump to Run in 24 Hours.	Gallons per Minute.	Time Pump to Run in 24 Hours.	Gallons per Minute.
2,000,000	20 Hours......	1666	20 Hours......	1666
1,750,000	20 Hours......	1458	20 Hours......	1458
1,500,000	20 Hours......	1250	20 Hours......	1250
1,250,000	20 Hours......	1042	20 Hours......	1042
1,000,000	20 Hours......	833	20 Hours......	833
900,000	20 Hours......	733	20 Hours......	733
800,000	20 Hours......	666	20 Hours......	666
700,000	20 Hours......	583	20 Hours......	583
600,000	20 Hours......	500		
			10 Hours......	1000
			10 Hours......	833
500,000	7 Hours......	1189	10 Hours......	750
450,000	7 Hours......	1071	10 Hours......	666
400,000	7 Hours......	928	10 Hours......	583
350,000	7 Hours......	838	10 Hours......	500
300,000	7 Hours......	714		
250,000	7 Hours......	595	4 Hours......	1041
200,000	7 Hours......	476	4 Hours......	833
150,000	7 Hours......	357	4 Hours......	625
100,000	7 Hours......	238	4 Hours......	416
50,000	7 Hours......	119	4 Hours..... .	208
25,000	7 Hours......	60	4 Hours......	104

Size of discharge pipe should be decided in accordance with the following:

Use 4-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 0.355
Use 6-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 0.437
Use 8-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 0.519
Use 10-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 0.656
Use 12-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 0.820
Use 14-in. Cast-iron Pipe where $Qd \times H$ is most nearly equal to 1.162

When $Qd =$ average quantity of water pumped per 24 hours in 1000 gallons and $H =$ friction head in feet for one foot of pipe for quantity of water plant is to handle per minute.

The static head should be obtained. Friction head should be calculated in accordance with friction tables and 50 per cent. added thereto for the ageing of the piping system.

The E. HP. will be

$$\frac{\text{Gallons per minute} \times (\text{static head} + \text{friction head in feet})}{3960}$$

Steam should be selected for power for plants up to 5 E. HP. when most of the following conditions obtain:

(a) Where 100 lbs. of coal unloaded into a pump house is cheaper than one gallon of gasoline delivered at gasoline storage tank, taking into consideration the number of hours the plant is to be operated and the location of plant as regards delivery of fuel; special attention also being paid to the proper design of pump as regards size of steam and water cylinders in large plants.

(b) Where a steam plant is maintained for other purposes, as at terminals where shops are run by steam.

(c) Where interest charge on a steam plant is less than it would be on a gasoline plant.

Gasoline should be selected as a motive power where most of the following conditions obtain:

(a) Where one gallon of gasoline delivered at gasoline storage tank is cheaper than 100 lbs. of coal unloaded into the pump house, special consideration being given to locations remote from trackage and isolated stations where train service is such that pumper can, by pumping the whole of his time between trains, do the pumping at two or three stations.

(b) Where the quality of the water is such that it will necessitate heavy boiler repairs, provided boiler compounds cannot be successfully used.

(c) Where interest charge on a gasoline plant is less than it would be on a steam plant.

The boiler selected should have the relation to E. HP., as shown by the following table, and should carry 100 lbs. steam.

SIZE OF VERTICAL SUBMERGED FLUE AND LOCOMOTIVE TYPE BOILERS FOR RAILROAD PUMPING PLANTS FROM 1 TO 15 EFFECTIVE HP.

NOTE:—These calculations are based on boiler pressure, 100 lbs.; pump cylinder pressure, 90 lbs.; coal, 11,000 B. T. U., 25 per cent. added for contingencies; pump efficiency, 66⅔ per cent.

E. HP. = Gal. per Min. × Head in Ft. ÷ 4000	I. HP. at 66⅔% Pump Efficiency	Lbs. Water per Hour at 65° F. to Steam at 100 lbs., to be Evaporated at 36½ lbs. per I. HP.	Sq. Ft. Heat Surface Required for Evaporation at 2.88 Lbs. Water per Hour, per Sq. Ft. Heating Surface	Boiler HP. at 10 Sq. Ft. Heat Surface per HP. per Hour. 25% Added for Contingencies		Lbs. of Coal at 11,000 B. T. U. Burned per Hour to Evaporate Water, Using 2.8 lbs. per E. HP. Hour	Sq. Ft. Grate Area Required for Consumption of 13 lbs. Coal per Sq. Ft. per Hour (Given as Most Economical by Christie Tests.)	Sq. Ft. Grate Area Usually Furnished in Boilers		Lbs. of Coal of 11,000 B. T. U. Burned per Sq. Ft. Grate per Hour to Evaporate Water in Boilers as Usually Furnshd.	
				Actual	Nearest Com'l			Vertical	Loco	Vertical	Loco
1	1.5	55	19	2.8	5	28	2.15	1.76	Not Made	15.8	Not Made
2	3.0	110	38	4.8	5	56	4.32	1.76		31.8	
3	4.5	164	57	7.2	8	84	6.47	3.14		26.7	
4	6.0	219	76	9.5	10	112	8.52	3.14		35.6	
5	7.5	274	95	12.0	12	140	10.80	3.14		44.5	
6	9.0	329	114	14.0	15	168	12.90	4.90	6.3	34.2	26.6
7	10.5	384	134	16.8	20	196	15.00	7.10	9.2	27.6	21.3
8	12.0	438	152	19.0	20	224	17.20	7.10	9.2	31.5	24.3
9	13.5	492	170	21.3	25	252	19.40	7.10	9.2	35.4	27.4
10	15.0	548	188	23.5	25	280	21.60	7.10	9.2	39.5	30.5
11	16.5	603	208	26.1	30	308	23.70	9.60	12.2	32.0	25.2
12	18.0	654	227	28.4	30	336	25.80	9.60	12.2	34.8	27.5
13	19.5	713	247	30.8	35	364	27.00	9.60	12.2	37.9	29.8
14	21.0	768	265	33.2	35	392	30.00	9.60	12.2	40.8	32.1
15	22.5	822	285	35.6	40	420	32.30	9.60	12.2	43.7	34.3

The steam pump selected should have the ratio of water to steam cylinders as large as possible. The water cylinder should be of proper size to discharge the required amount of water per minute, assuming 70 strokes per minute for each cylinder. Pump efficiency should be assumed as 66⅔ per cent. Assuming initial steam pressure at 90 lbs. per sq. in. obtain steam cylinder pressure per pound water pressure. Proper ratio of water to steam cylinder should be as per diagram 4. The size of steam cylinder should be in accordance with this size of water cylinder and ratio (see table 3).

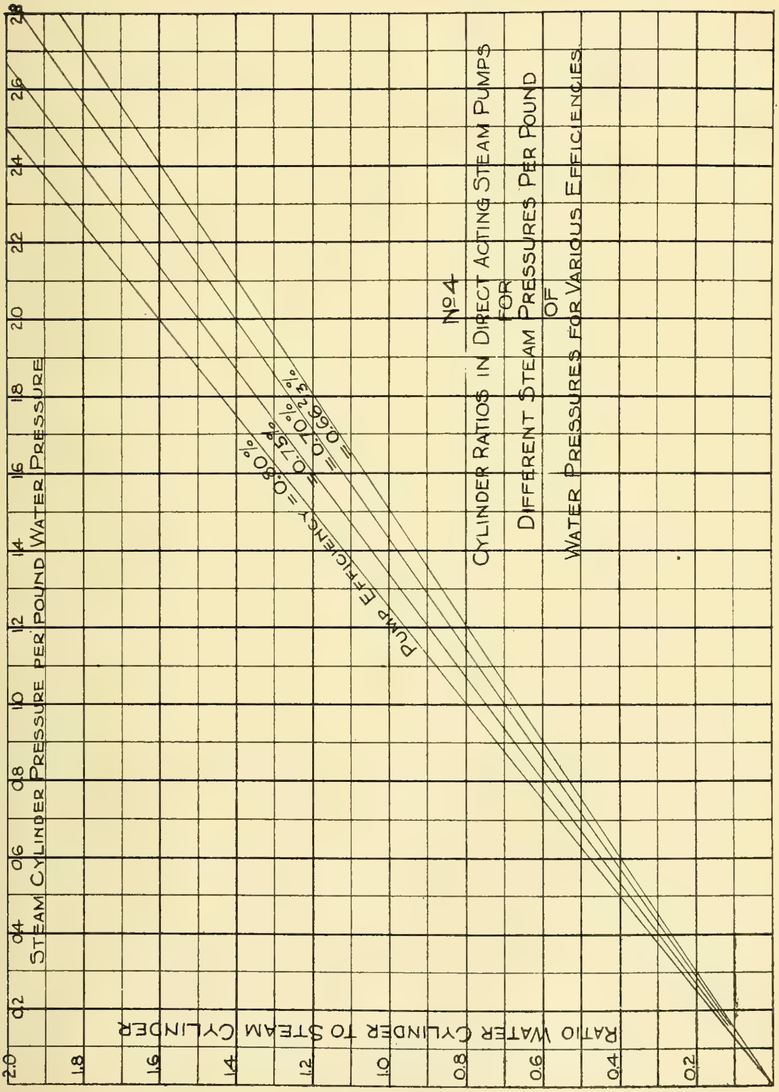

TABLE 3

TABLE SHOWING RATIO OF AREA OF WATER CYLINDERS TO STEAM CYLINDERS FOR VARIOUS STANDARD SIZES DIRECT ACTING STEAM PUMPS

$$\text{Ratio} = \frac{\text{Area of Water Cylinder}}{\text{Area of Steam Cylinder}}$$

DIAMETER CYLINDERS		RATIO	DIAMETER CYLINDERS		RATIO	DIAMETER CYLINDERS		RATIO
Steam	Water		Steam	Water		Steam	Water	
6	5	0.69	6	7½	1.56	7	10	2.04
7	5	0.51	7½	7½	1.00	8	10	1.56
7½	5	0.44	8	7½	0.88	10	10	1.00
8	5	0.39	12	7½	0.39	12	10	0.69
9	5	0.31	14	7½	0.29	14	10	0.51
10	5	0.25	16	7½	0.22	16	10	0.39
						17	10	0.35
5	5½	1.21	6	8	1.78	18	10	0.31
5½	5½	1.00	8	8	1.00	20	10	0.25
6	5½	0.84	10	8	0.64	22	10	0.21
10	5½	0.30	12	8	0.44			
12	5½	0.21	14	8	0.33	7½	10¼	1.87
			16	8	0.25	9	10¼	1.30
5¼	5¾	1.20				10	10¼	1.05
6	5¾	0.92	6	8½	2.01	12	10¼	0.73
7½	5¾	0.59	7	8½	1.48	14	10¼	0.54
			7½	8½	1.28	16	10¼	0.41
6	6	1.00	8	8½	1.13	17	10¼	0.36
7	6	0.73	9	8½	0.89	18½	10¼	0.31
7½	6	0.64	10	8½	0.72	20	10¼	0.26
8	6	0.56	12	8½	0.50			
9	6	0.44	14	8½	0.37	17	11	0.42
10	6	0.36	16	8½	0.28	20	11	0.30
12	6	0.25	17	8½	0.25			
			18	8½	0.22	8	12	2.25
5¼	6¾	1.65	18½	8½	0.21	9	12	1.78
7	6¾	0.93				10	12	1.44
			14	9	0.41	12	12	1.00
6	7	1.36	16	9	0.32	14	12	0.73
7	7	1.00	18	9	0.25	16	12	0.56
7½	7	0.87	20	9	0.20	17	12	0.50
8	7	0.77				18	12	0.44
10	7	0.49	12	9¼	0.59	18½	12	0.42
12	7	0.34	14	9¼	0.44	20	12	0.36
14	7	0.25	16	9¼	0.33	22	12	0.30
			18½	9¼	0.25	24	12	0.25
			20	9¼	0.21	26	12	0.21

The gasoline engine selected should have a commercial brake horsepower rating of twice the effective horsepower. Engine and gearing for reduction of speed should be on one base with friction clutch connection to pump shaft.

The power pump, where suction lift is such that the pump can be on same level as engine, may be of the triple single-acting type, or duplex double-acting, direct-connected to engine friction clutch. For small plants the combined engine and pump are recommended.

The power pump, where suction lift is such that the pump must be at a lower level than engine, should be single cylinder, double-acting type, connected to engine by means of a pitman face plate and shaft.

Pump houses should be constructed of non-combustible material. In gasoline plants the engine should be in a separate room, with floor vents. Stoves and lights should not be permitted in gasoline engine rooms. The gasoline supply should be kept outside the house. Where there are deep wells, the house should be so designed that it can be removed or opened to admit of a well machine being placed over it. At terminal stations the pump house should be incorporated with other part of plant where possible.

Each plant should be fitted with a pressure gage on discharge pipe and a revolution counter on pump.

*WATER SERVICE RECORDS.

Accurate records of water stations and costs of pumping should be at hand in the office of the official having charge of this branch of the service, and forms M. W. 1301, M. W. 1302, M. W. 1303, M. W. 1304, are recommended for this purpose.

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* Adopted, Vol. 10, 1909, pp. 776, 780, 821.

Form M. W. 1301.

PUMPER'S DAILY REPORT.

3 Inches X 3 Inches

Railway
Business

ADDRESS OF OFFICIAL

(Folding Line)

INSTRUCTIONS

Each pumper will fill out one of these reports each day for each plant worked at and forward to

(Name of official)

....

In the supply report fill in the column headed "Balance on hand last day of month" only on the report for the last of the month, showing the supplies on hand at the close of the work on the last day of the month.

PUMPING REPORT

	Hour.	Min.	Hour.	Min.	Hour.	Min.
Time started..						
Time stopped.						
Time ran......						
Counter at start..						
Counter when stopped.						
Dif'rence counter.						
Gage at start..						
Gage when stopped.						
Average gage.....						

(Folding Line)

Pounds Coal used........................

Gallons Gasoline used...................

Other Fuel used........................

STATION..............................

Date......................19....

Received To-day	Supplies Received	Balance on Hand Last Day of Month
	Kind	
	Tons Coal	
	Gal. Gasoline	
	Qt. Gas Eng. Oil	
	Qt. Cylinder Oil	
	Qt. Car Oil	
	Qt. Oil	
	Lbs. Waste	

Pumper

5½ Inches X 5½ Inches

REPORT SIDE ADDRESS SIDE

Size of Card 5½ x 6 inches, printed both sides.

Form M. W. 1302.

STATEMENT OF COST OF PUMPING WATER

STATION	DATE	TIME PUMP RAN		No Rev. of Counter	Gallons Per Rev	GALLONS PUMPED		Gage Press. in Feet	H.P. = Gal. per Min. × Head Feet - 3960	FUEL REPORTED AS USED			SUPPLIES RECEIVED																COST RECORD INCLUDING LABOR				
		Hr	Min.			Total	Per Min.			Coal Pounds	Gaso-line Gallons	Other Fuel	Coal @ $		Gasoline @ $		Other Fuel		Gas Engine Oil @		Cylinder Oil @		Car Oil @		Other Oil @		Waste @		Labor Cost	Total Mtl.	Per 1000 Gal.	Per Hour	Per H.P. Hour
													Tons	Cost	Gal.	Cost		Cost	Qts.	Cost	Qts.	Cost	Qts.	Cost	Qts.	Cost	Lbs.	Cost					

Form M. W. 1303.

WATER STATION RECORD

AT____________________

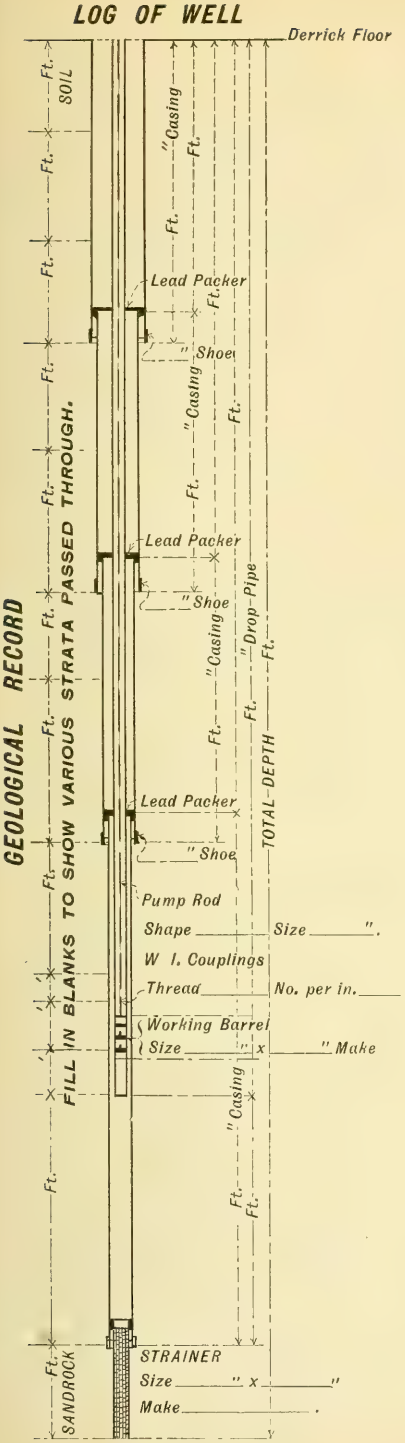
WHERE PAINTING RECORD IS DESIRED ENTER DATE PAINTED WITH PREFIX "P" IN DATE COLUMN.

WHERE SECOND-HAND EQUIPMENT IS INSTALLED ENTER DATE OF MANUFACTURE IN BRACKETS OVER INSTALLATION DATE.

WATER TANKS, SETTLING TANKS INCLUDED								WATER COLUMN										PUMP HOUSE							PUMP PIT				WIND MILLS					
			Tub						Pit				Column																Tower			Wheel		
Date	Foundation	Sub-struct.	Diam.	Hght.	Capacity Gallons	Frost Box	Plan Reference	Date	Width	Lght.	Depth	Matl.	Kind	Col. Diam.	Col. Supply	C.Col. Toe Tk	Top Rail to Bot. Spout	Date	Width	Length	Sill to Plate	Foundation	Above Found.	Roof	Date	Size	Depth	Material	Date	Kind	Hght.	Date	Kind	Diam.

BOILERS													PUMPS									ENGINES					TREATING PLANTS	
	Boiler							Stack			Injector								Size									
				Shell																								
Date Installed	Shop No.	Name Maker	Kind	Lgth	Diam.	Size Grate	No. & Size Flues	Date	Diam.	Height	Size	Kind	Date	Maker and Shop Number	Kind of Power	Simplex or Compound Expansion	Single or Double Action	No. of Water Cylinders	Steam	Water	Stroke	Date	Maker and Shop Number	Kind	Rated H.P.	Connections from Engine to Pump	Date	Maker and Plan Reference

WATER SUPPLY														HEIGHTS			ANALYSIS		PIPE LINES SEE__________FOR LOCATION																			COST RECORD		
		Dug Wells				Pipe Wells								Top Tank to					Steam			Exhaust			Suction			Discharge			Column Supply			Other Lines						
		Diam.						Diam.																																
Date	Source	Top	Bottom	Total Depth	Material	Date	Number	Top	Bottom	Total Depth	Working Barrel Below Top Well	Kind Point, Screen or Strainer	Make of Packing Head	High Water	Low Water	Center Pump	Lbs. incrust. Solids per 1000 gal.	Fitness for Engine Use	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Use	Length	Date	Work Done	Original Construction Cost


LOG OF WELL
Derrick Floor
GEOLOGICAL RECORD
FILL IN BLANKS TO SHOW VARIOUS STRATA PASSED THROUGH.
SOIL
Ft.
" Casing
Lead Packer
" Shoe
" Drop-Pipe
TOTAL-DEPTH
Pump Rod
Shape
Size ".
W. I. Couplings
Thread
No. per in.
Working Barrel
Size " x " Make
STRAINER
Size " x "
Make
SANDROCK

Form M. W. 1304.

RECORD OF DEEP WELLS.

Location ....

Date began drilling....................

Well completed ....

WATER LEVELS.

Water stands at.....................ft.

And pumps down to.................ft.

When delivering ....gals. per minute.

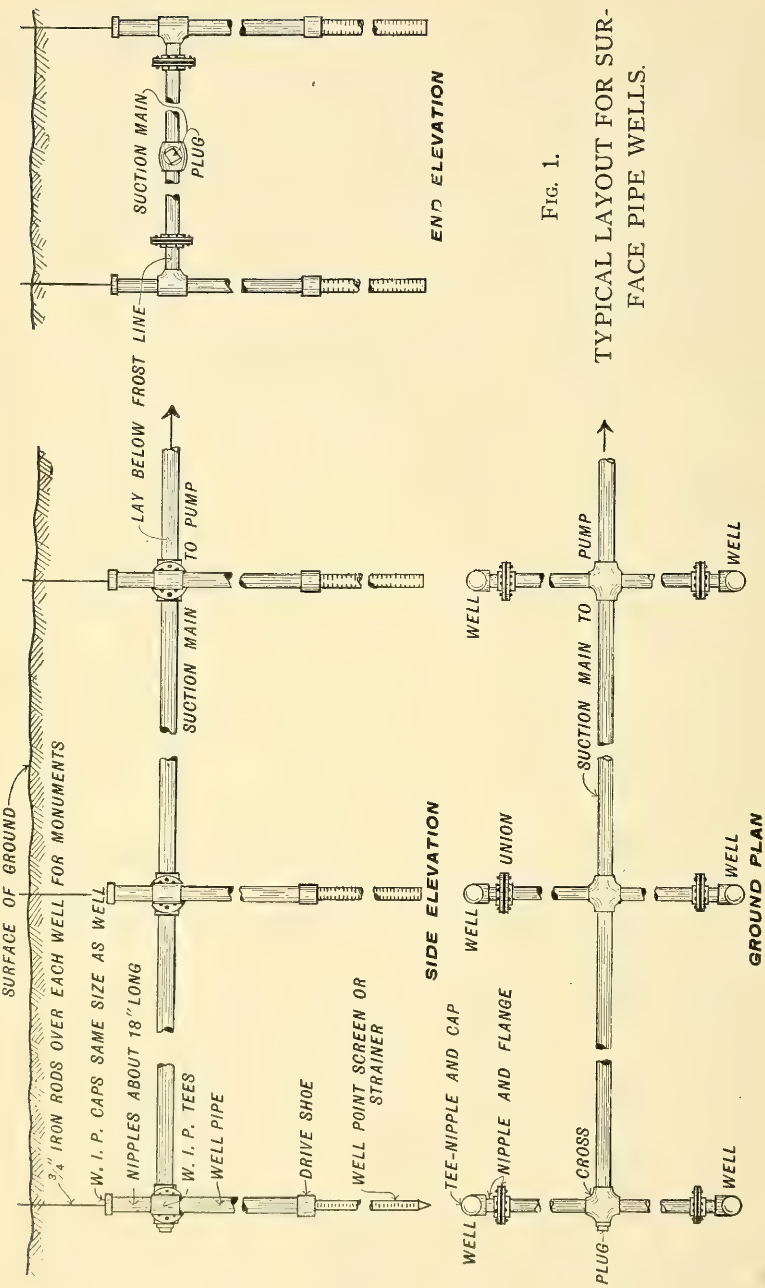

SURFACE OF GROUND
3/4" IRON RODS OVER EACH WELL FOR MONUMENTS
W. I. P. CAPS SAME SIZE AS WELL
NIPPLES ABOUT 18" LONG
W. I. P. TEES
WELL PIPE
DRIVE SHOE
WELL POINT SCREEN OR STRAINER
SUCTION MAIN
LAY BELOW FROST LINE
TO PUMP
SIDE ELEVATION
SUCTION MAIN
PLUG
END ELEVATION
WELL
TEE-NIPPLE AND CAP
NIPPLE AND FLANGE
CROSS
PLUG
WELL
WELL
UNION
WELL
SUCTION MAIN TO PUMP
WELL
WELL
GROUND PLAN

Fig. 1.

TYPICAL LAYOUT FOR SURFACE PIPE WELLS.

*FRICTION IN PIPE LINES AND COLUMNS.

DEFINITIONS.

The Head at any point in the pipe of a gravity water supply system is the vertical distance, in feet, of the center of the pipe at that point below the plane of the free water surface.

The Pressure Head, at any point in the pipe of a gravity water supply system, is the head in feet which corresponds to the pressure in pounds per square inch at that point, and is obtained by multiplying the pressure by 2.304.

The Velocity Head is the term used to designate the expression

$$\frac{v^2}{2g}$$

obtained from the formula giving the theoretic velocity of flow, $v = \sqrt{2gh}$, in which v = the velocity of flow in feet per second, g = the acceleration of gravity in feet per second (mean value 32.16).

The Velocity Head at any point in the pipe of a gravity water supply system is the head which could produce a theoretic velocity equal to the velocity at that point.

The Flow Head in a gravity water supply system is the difference in elevation which causes flow. It is the vertical distance, in feet, of the center of the end of a pipe, which discharges freely into the air, below the plane of the free water service at the other end. If the discharge is submerged it is the vertical distance between the planes of the free water surfaces.

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* Adopted, Vol. 11, Part 2, 1910, pp. 1167, 1169, 1190, 1216, 1226, 1227.

FORMULA.

The flow head equals the sum of the lost heads plus the velocity and pressure heads of the issuing stream.

$$H = m\frac{v^2}{2g} + \frac{V^2}{2g} + h_e + h_t + h_p + h_n + h$$

in which H = Flow head in feet.

h = Pressure head of issuing stream = O.

$m\frac{v^2}{2g}$ = Head (in feet) lost at entrance to pipe line in which m is a constant which varies from 1.00 for a pipe extending into the tank, to 0.00 for a perfect mouthpiece. $\frac{v^2}{2g}$ may be obtained from diagram for "velocity head in feet;" see Fig. 28.

$\frac{V^2}{2g}$ = Velocity head (in feet) of issuing stream; see Fig. 28.

h_e = Head lost (in feet) in overcoming friction in all elbows; see Fig. 28.

h_t = Head lost (in feet) in overcoming friction in all tees; see Fig. 28.

h_p = Head lost (in feet) in overcoming friction in all pipe lines; see Figs. 26 and 27.

h_n = Head lost (in feet) for the type of column used; see Figs. 2, 4, 6, 8, 10, 12, 14, 16, 18, 20.

Problem 1. Given the composition of delivery line from storage tank and the required discharge. To find the Flow Head.

From Fig. 28 find the velocity head at entrance, which multiplied by the usual value of m, viz., 1.0, gives the loss at entrance. From the same figure find the velocity head of the issuing stream; also the head lost in one elbow or tee of each size used, and multiply by the total number of each. From Figs. 26 and 27 find the head lost in 100 ft. of pipe for the various sizes in the line, and with this find the loss in each length of same size and add these totals to get the total friction in straight pipe. From one of the figures 3 to 21 find the head lost in type of water column to be used. The sum of these lost heads and the velocity head equals the flow head.

Problem 2. Given the composition of delivery line from storage tank and the height of water in same above the rail. To find the discharge:

(a) Find available flow head by deducting the height of free discharging end from height of water in the tank. (b) Assume a discharge and compute flow head as in Problem 1. (c) Divide the loss in the column for assumed discharge by this computed flow head. This will give the trial ratio. (d) Multiply available flow head by this trial ratio. This will give the column loss which may be expected with the available head. (e) With column loss find corresponding discharge from column loss diagram. (f) As a check, use computed discharge, solve as in Problem 1 and obtain flow head. This should come out approximately equal to given flow head (a). If the result is not close enough to take the value found (e) as the assumed discharge and again run through steps indicated. This will rarely be necessary.

A critical inspection of the head lost in each portion of the delivery line will develop where to economically decrease the loss in head by increasing the sectional area.

The diagrams of pipe friction refer to new cast-iron pipe. Allowance must be made for pipes becoming tuberculated and for incrustations of treated water. (The former alone may decrease the discharge 20 per cent. in 20 years.) These facts and the possibility of future demand for discharge larger than required when designed, suggest the advisability of selecting pipes larger than developed by the calculations.

DIAGRAMS OF FRICTION OF WATER IN NEW STRAIGHT CAST-IRON PIPE.

Fig. 26 for discharges from 100 to 1,000 gallons per minute.

Fig. 27 for discharges from 1,000 to 10,000 gallons per minute.

Diagrams in Fig. 28 of velocity heads and of friction due to tees and to 90° elbows with

Axial radius of curvature = 1½ diameters.
Axial radius of curvature = 3 diameters.

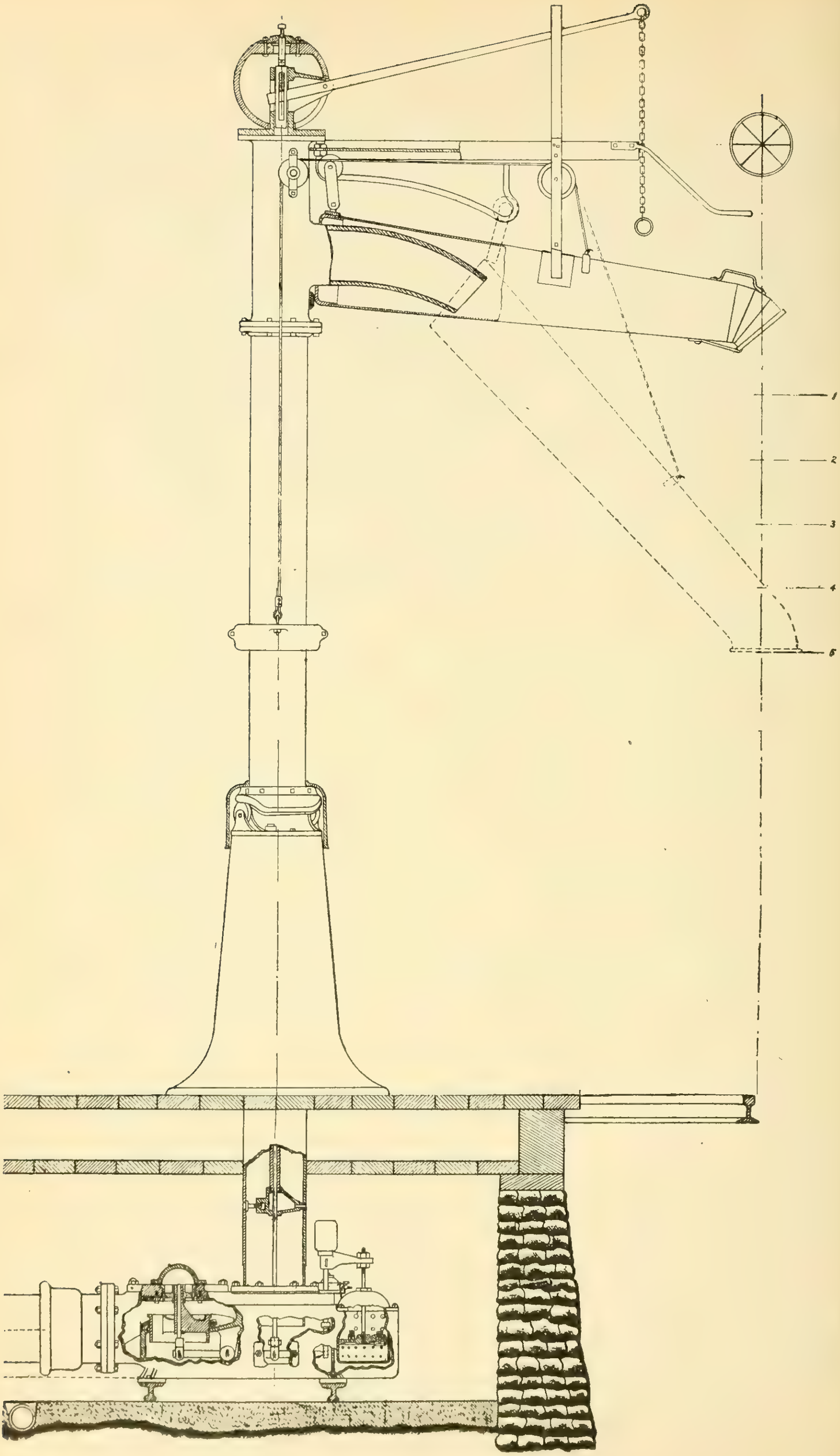


Fig. 2.—Water Column, Type A. (See Fig. 22 for details.)

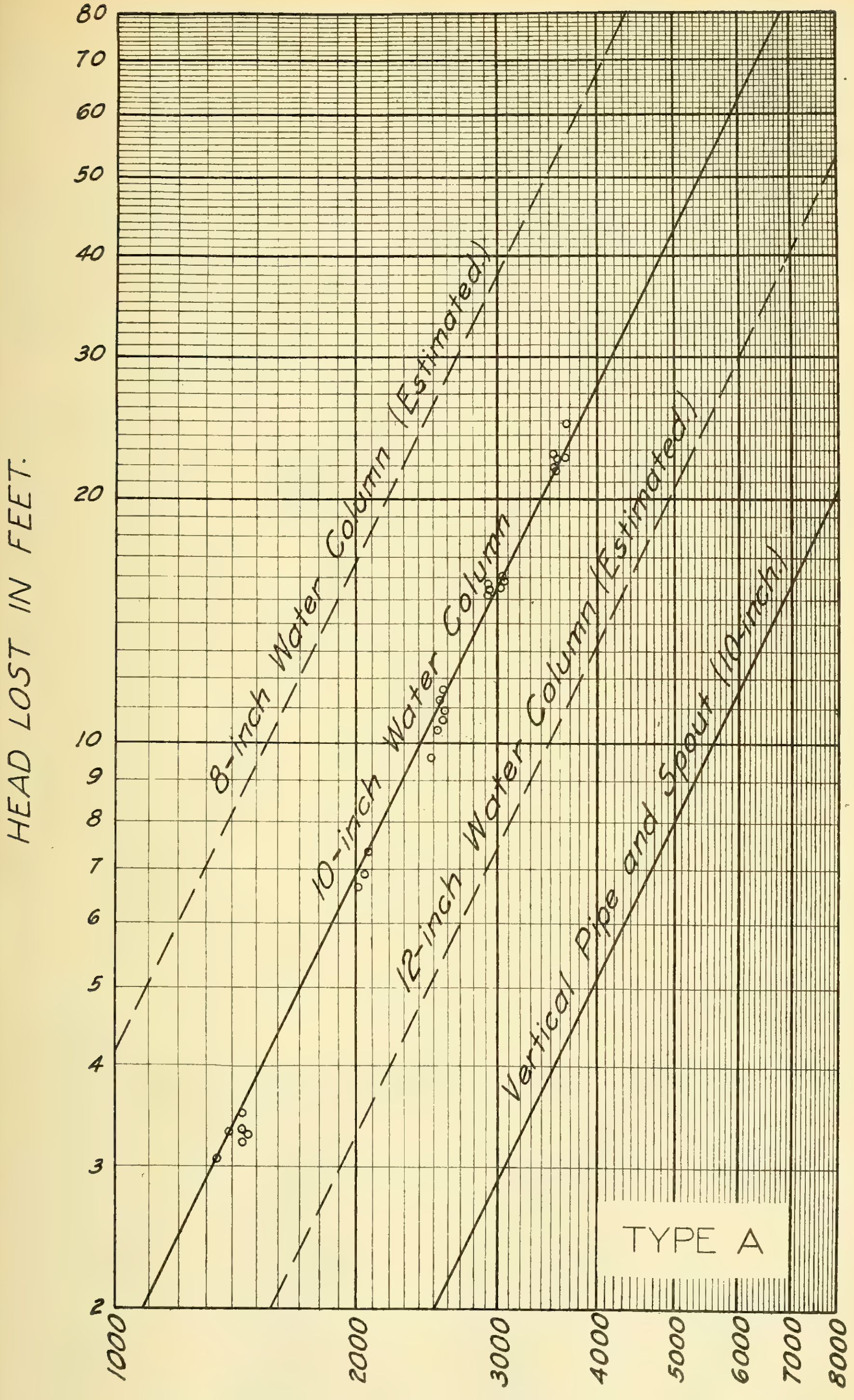


Fig. 3.—Loss of Head in Water Column, Type A.

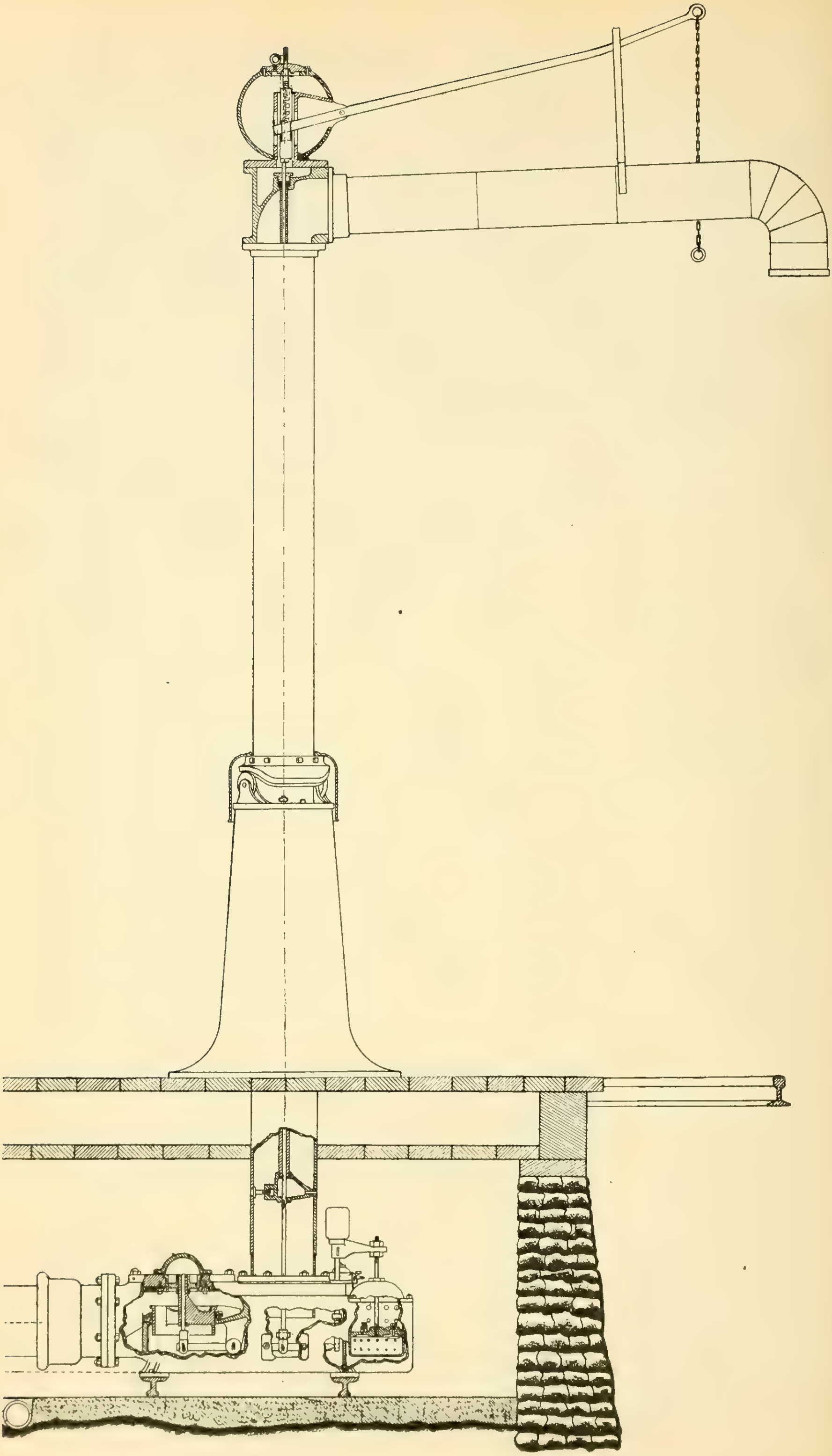


Fig. 4.—Water Column, Type B. (See Fig. 22 for details.)

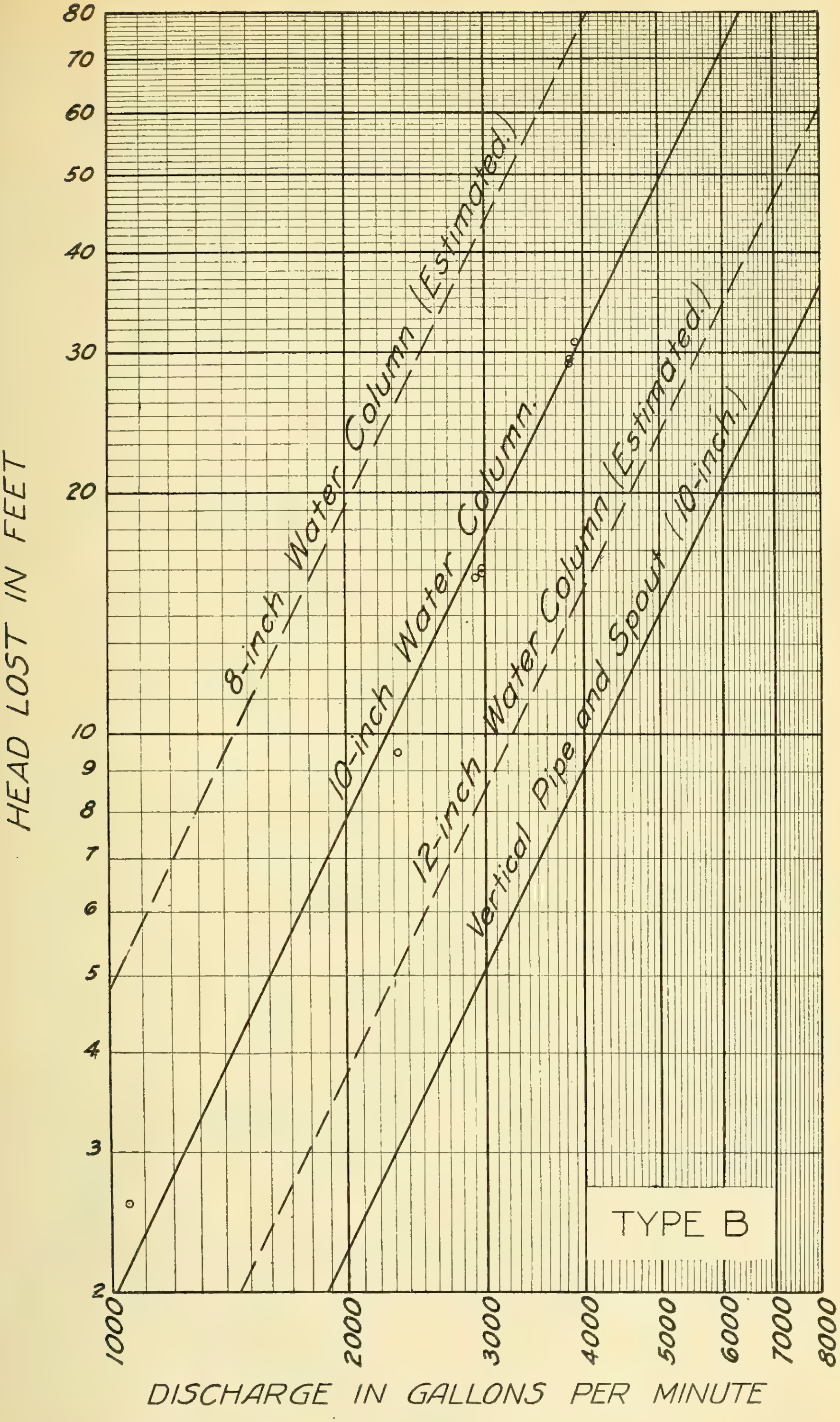


Fig. 5.—Loss of Head in Water Column, Type B.

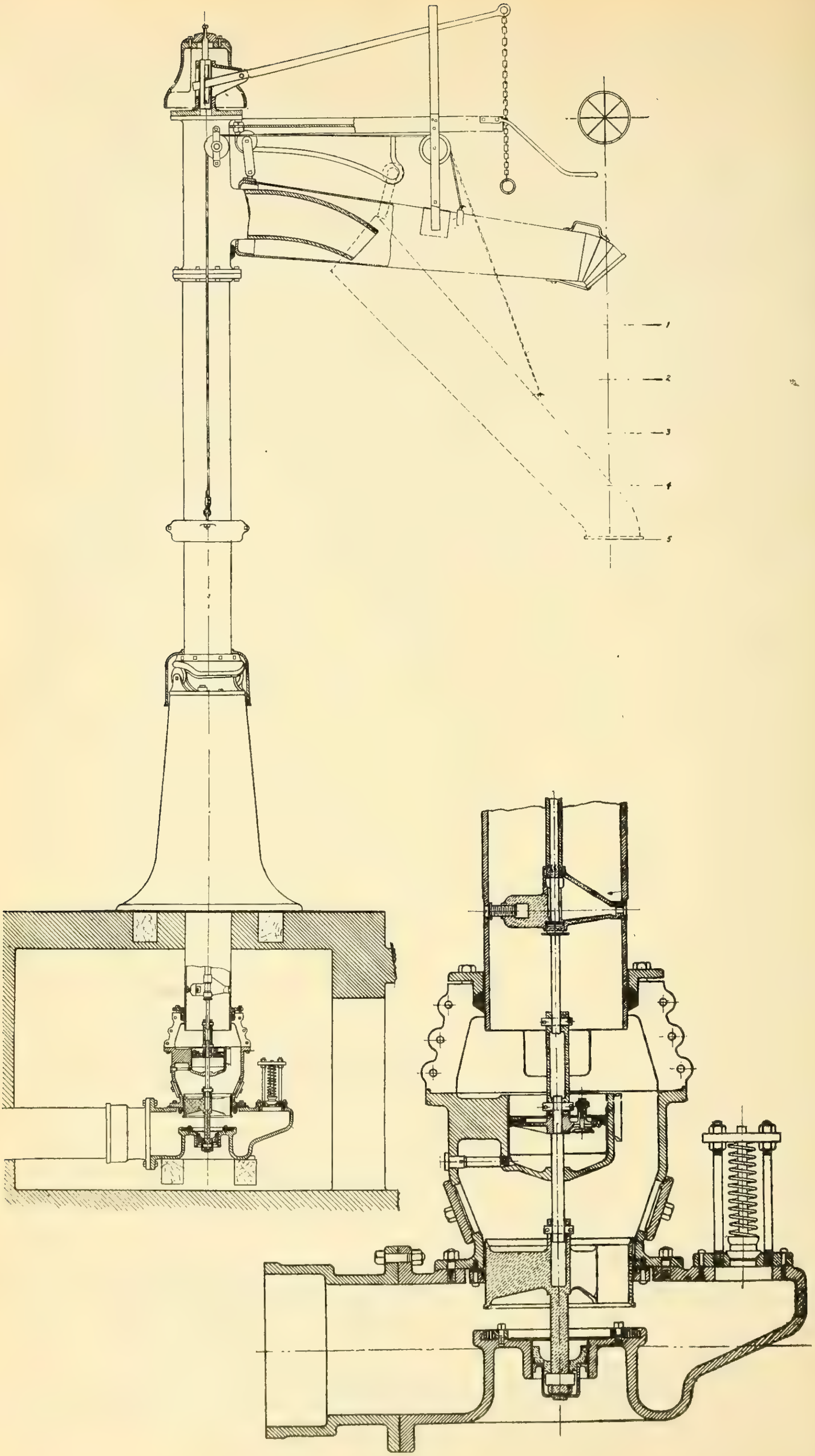


Fig. 6.—Water Column, Type C.

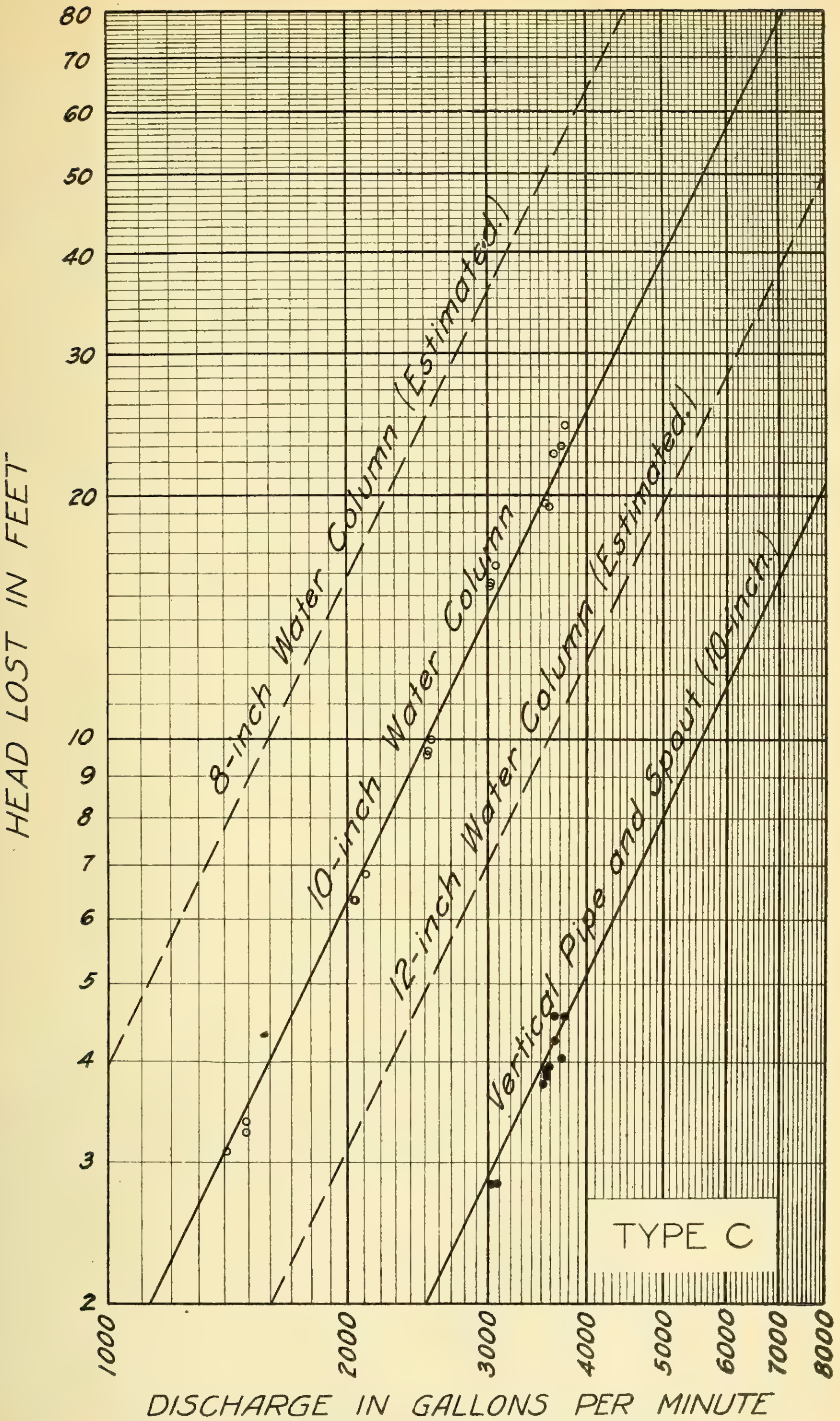


FIG. 7.—LOSS OF HEAD IN WATER COLUMN, TYPE C.

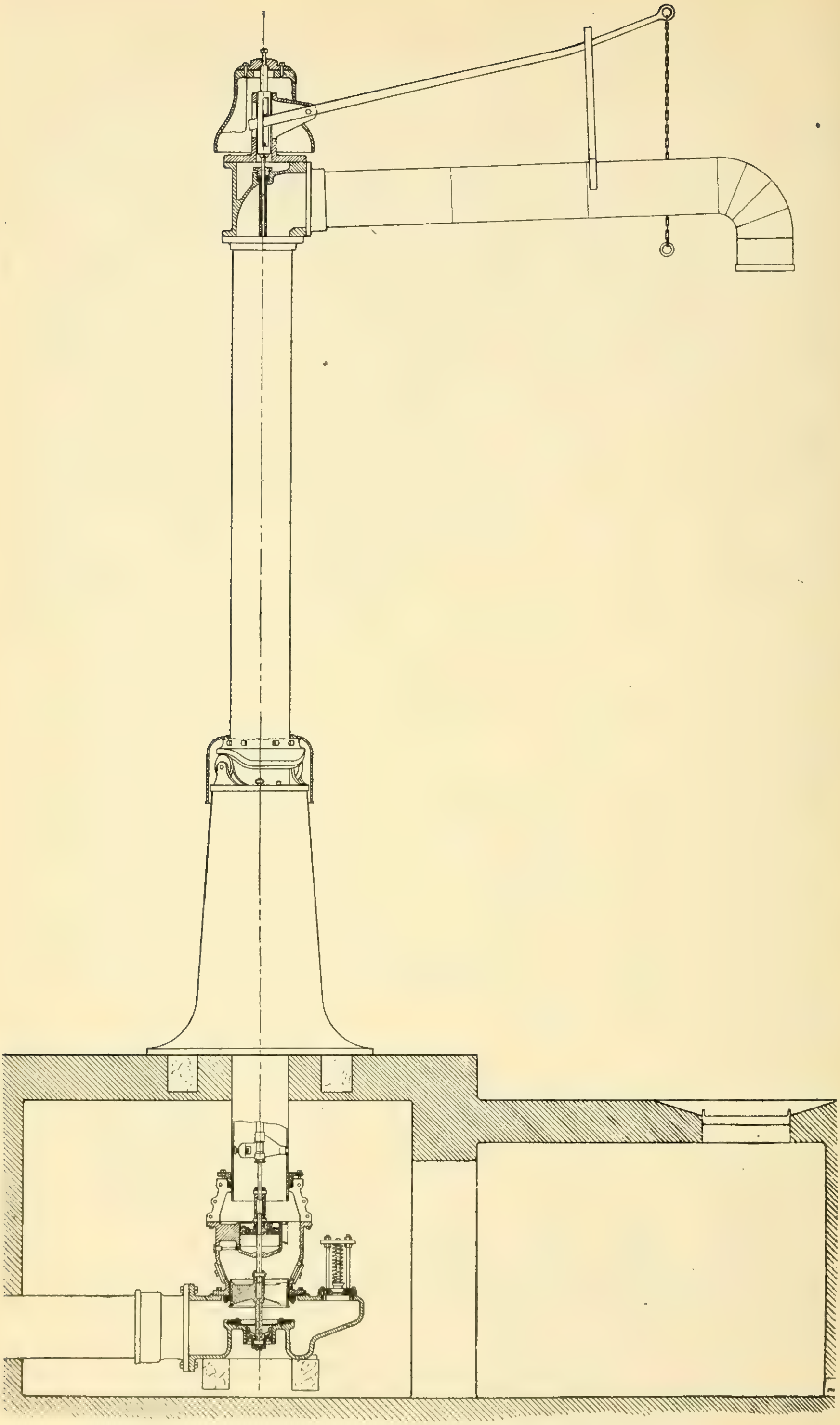


FIG. 8.—WATER COLUMN, TYPE D. (See Fig. 6 for details.)

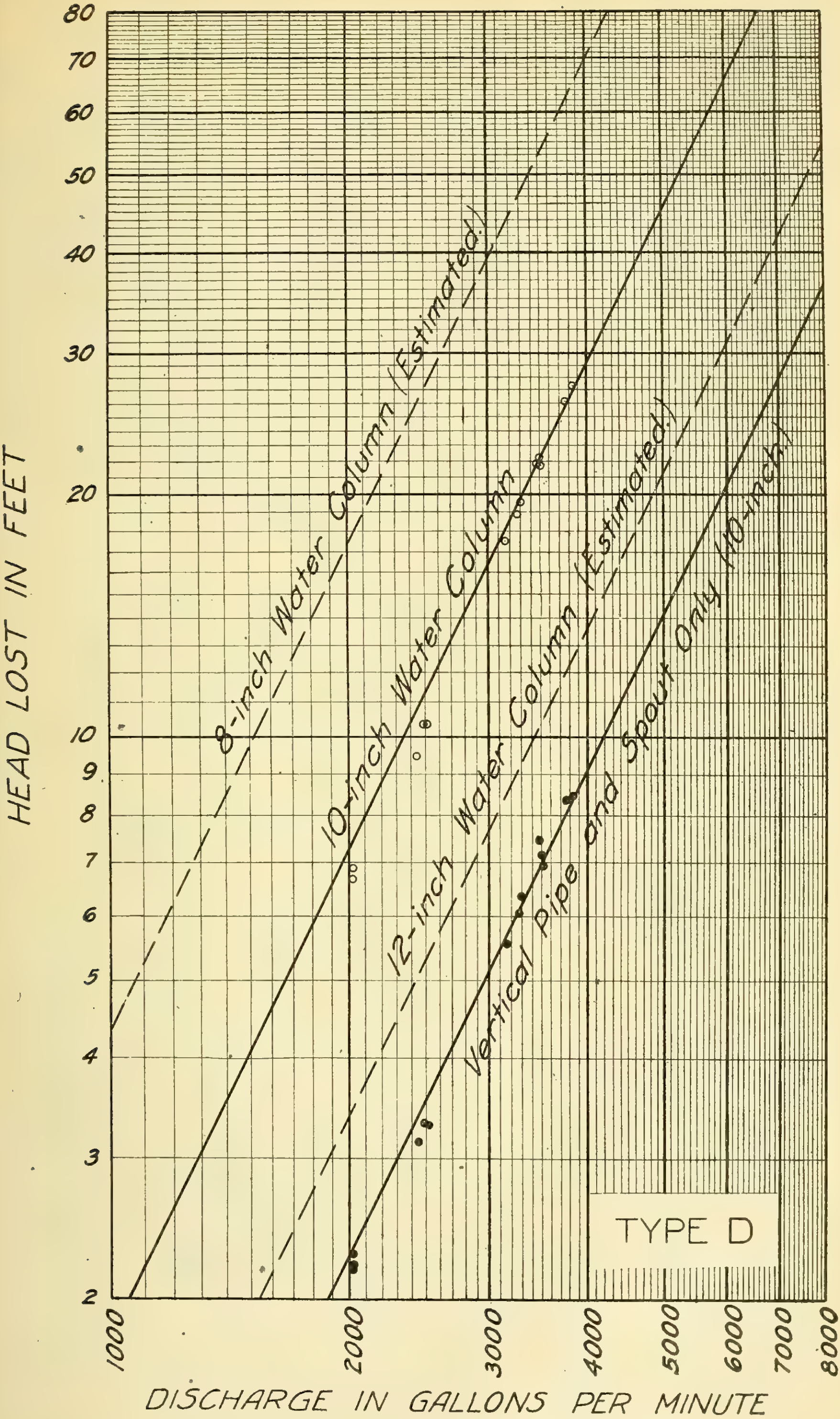


FIG. 9.—LOSS OF HEAD IN WATER COLUMN, TYPE D.

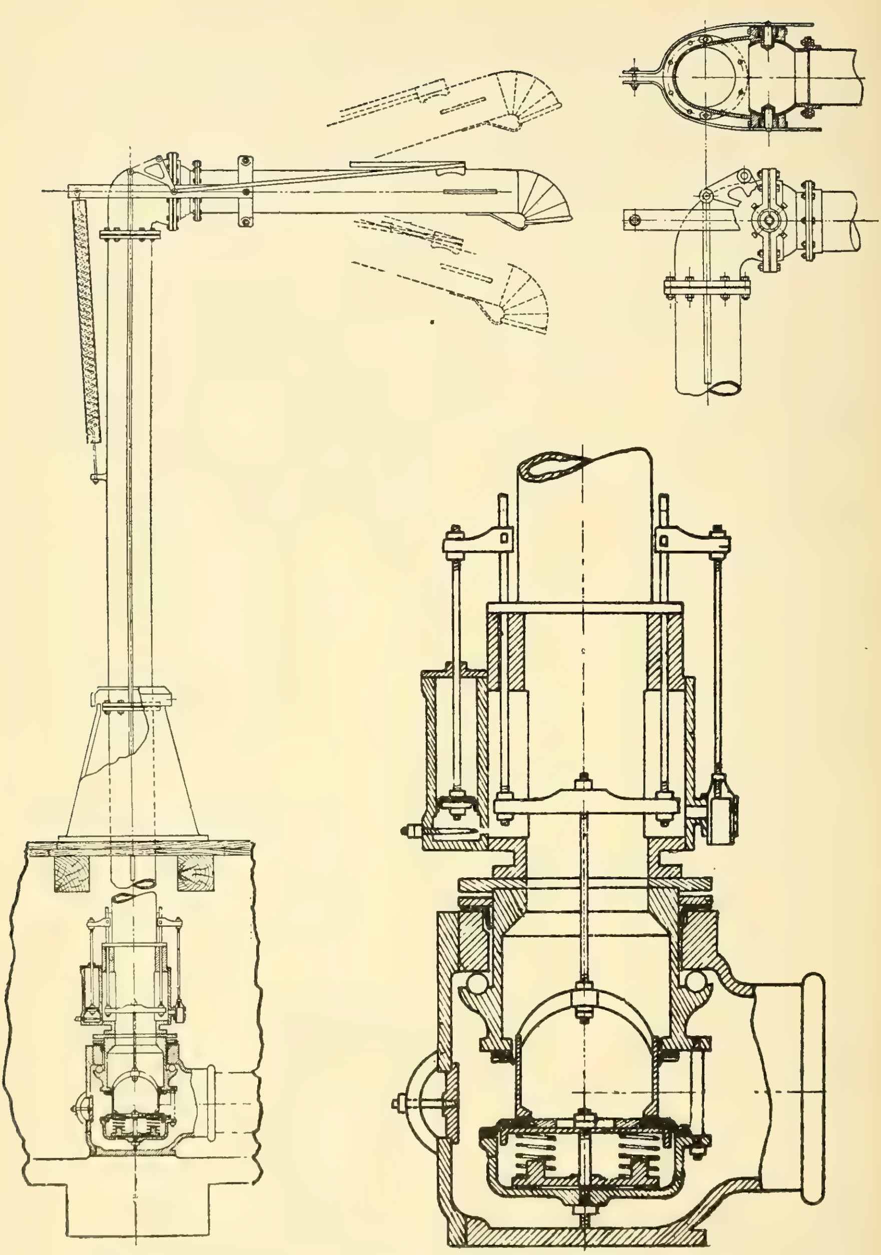


Fig. 10.—Water Column, Type E.

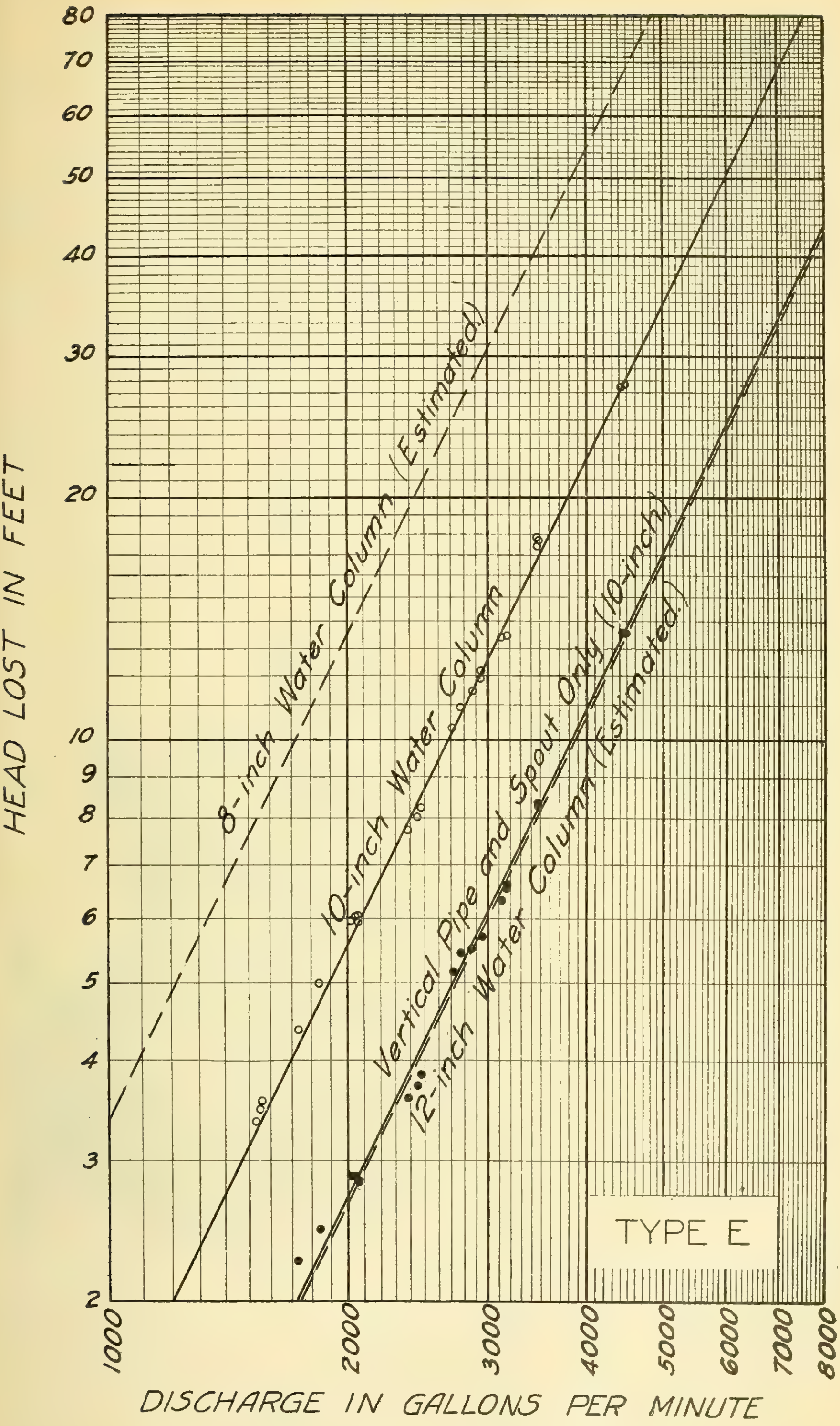


FIG. 11.—LOSS OF HEAD IN WATER COLUMN, TYPE E.

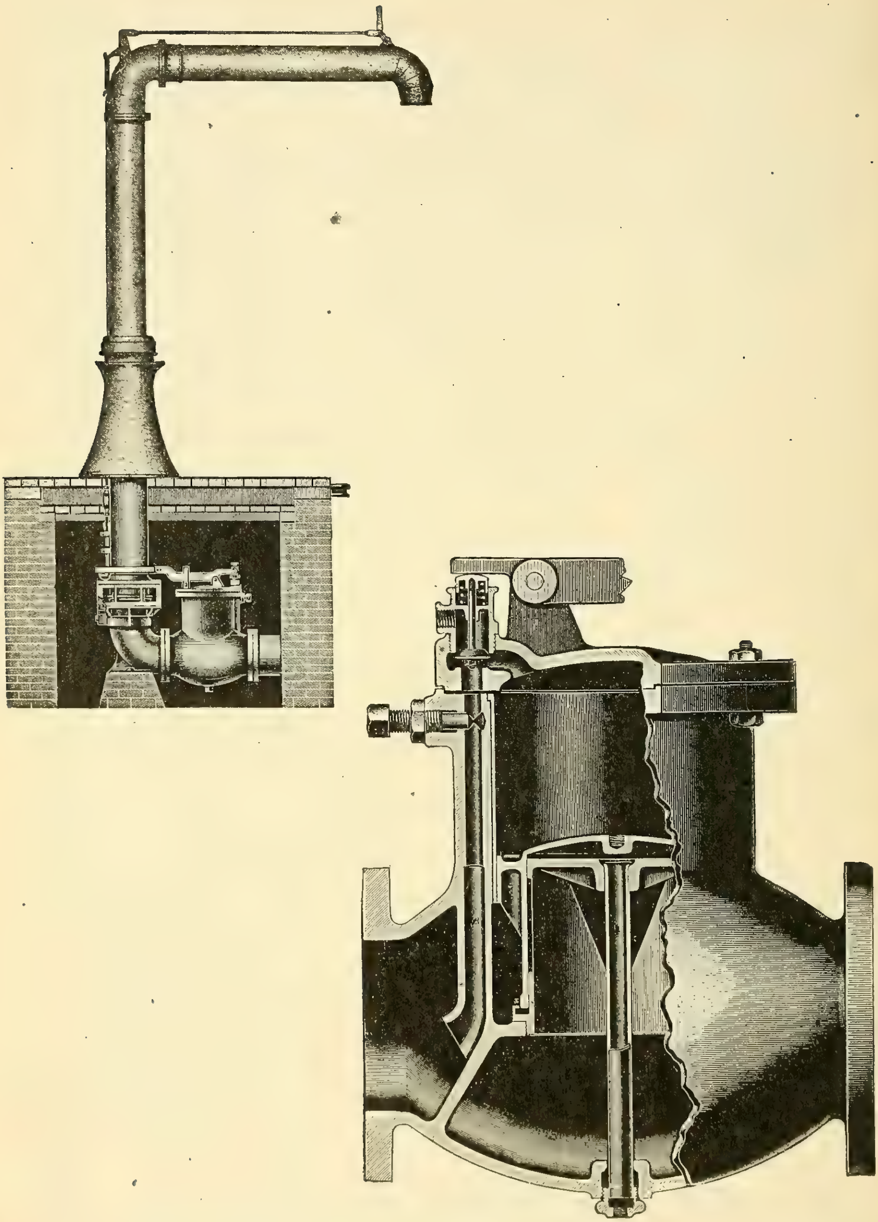


FIG. 12.—WATER COLUMN, TYPE F.

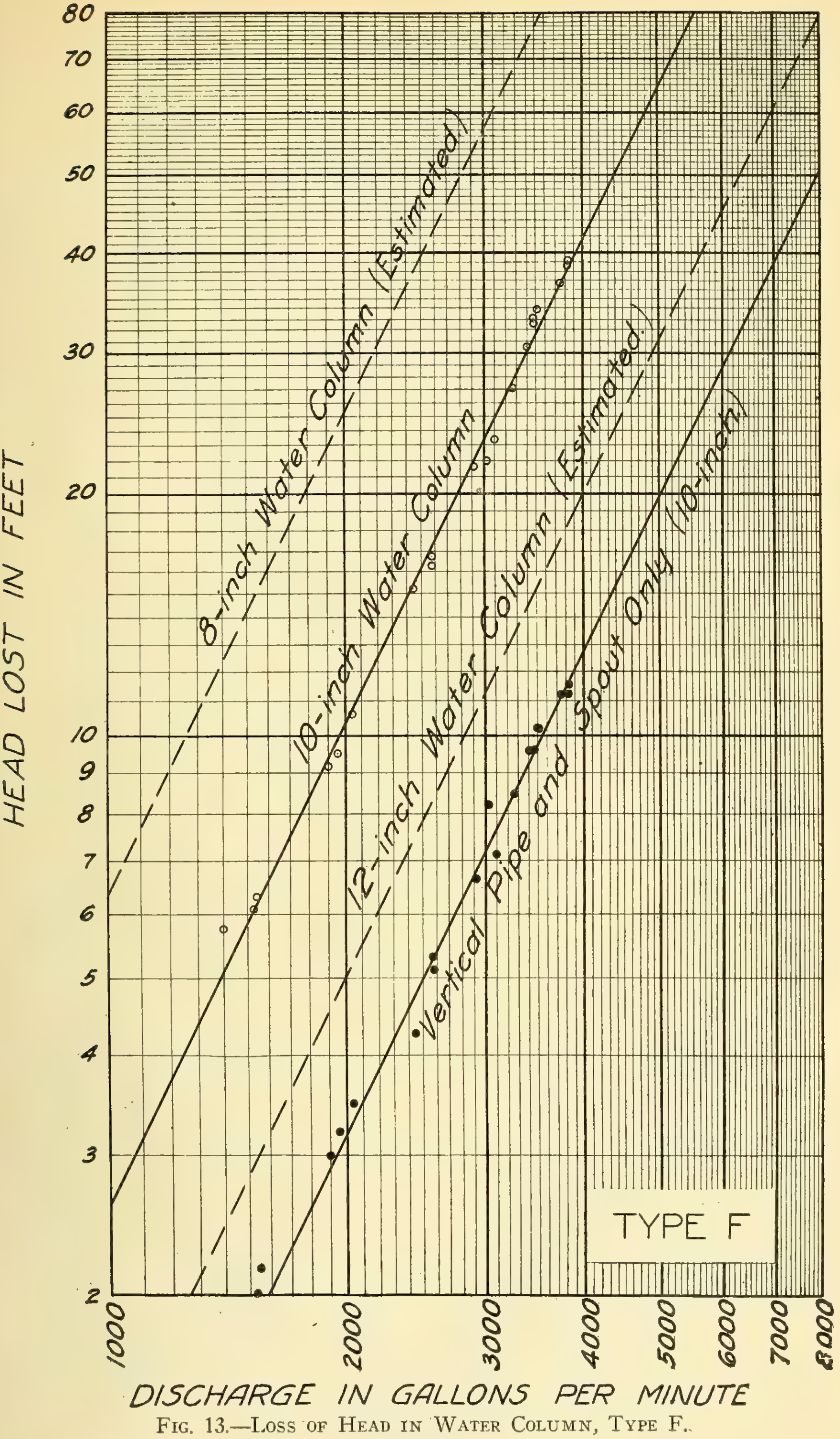


FIG. 13.—LOSS OF HEAD IN WATER COLUMN, TYPE F.

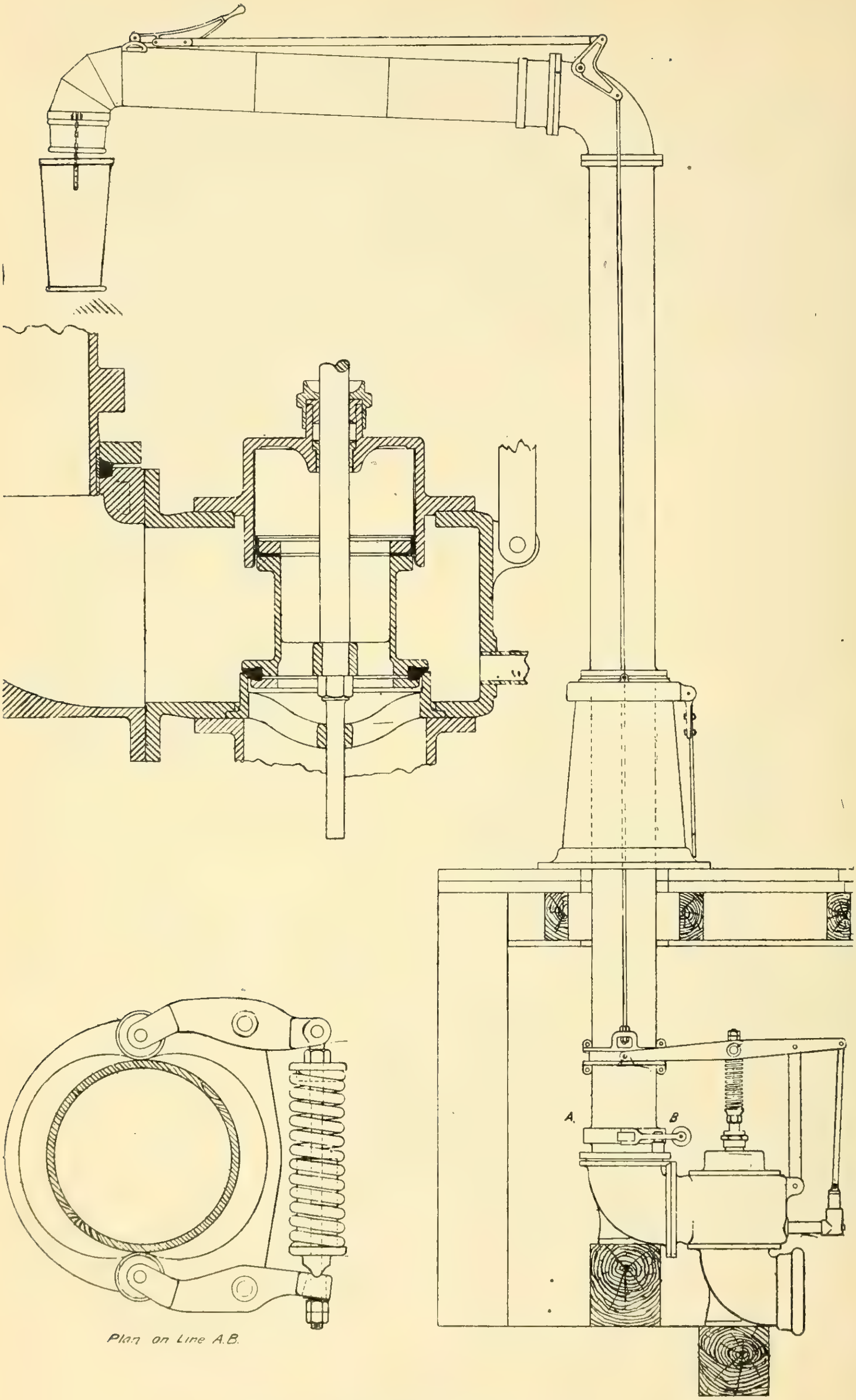

A.
B
Plan on Line A.B.

FIG. 14.—WATER COLUMN, TYPE G.

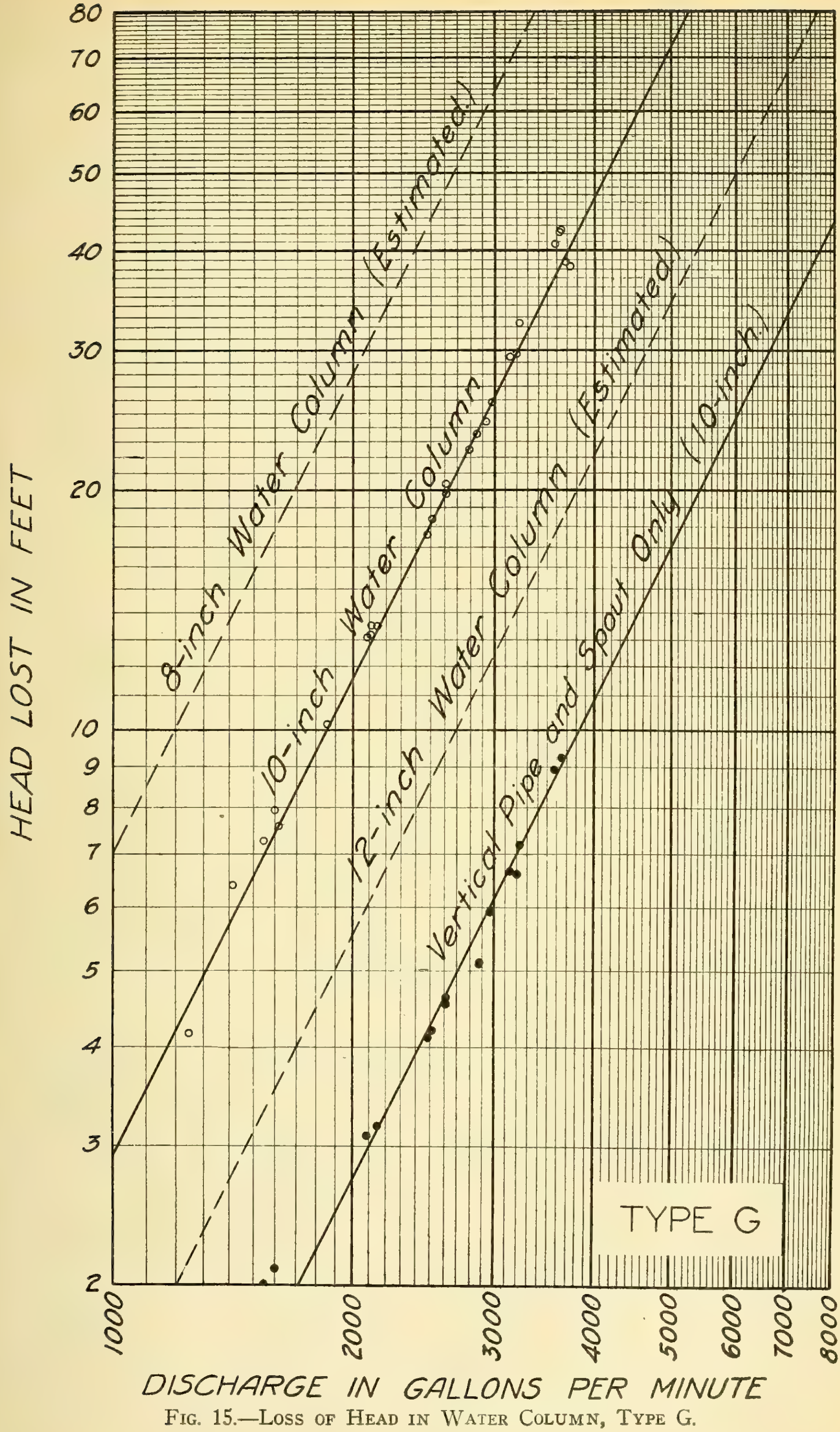


Fig. 15.—Loss of Head in Water Column, Type G.

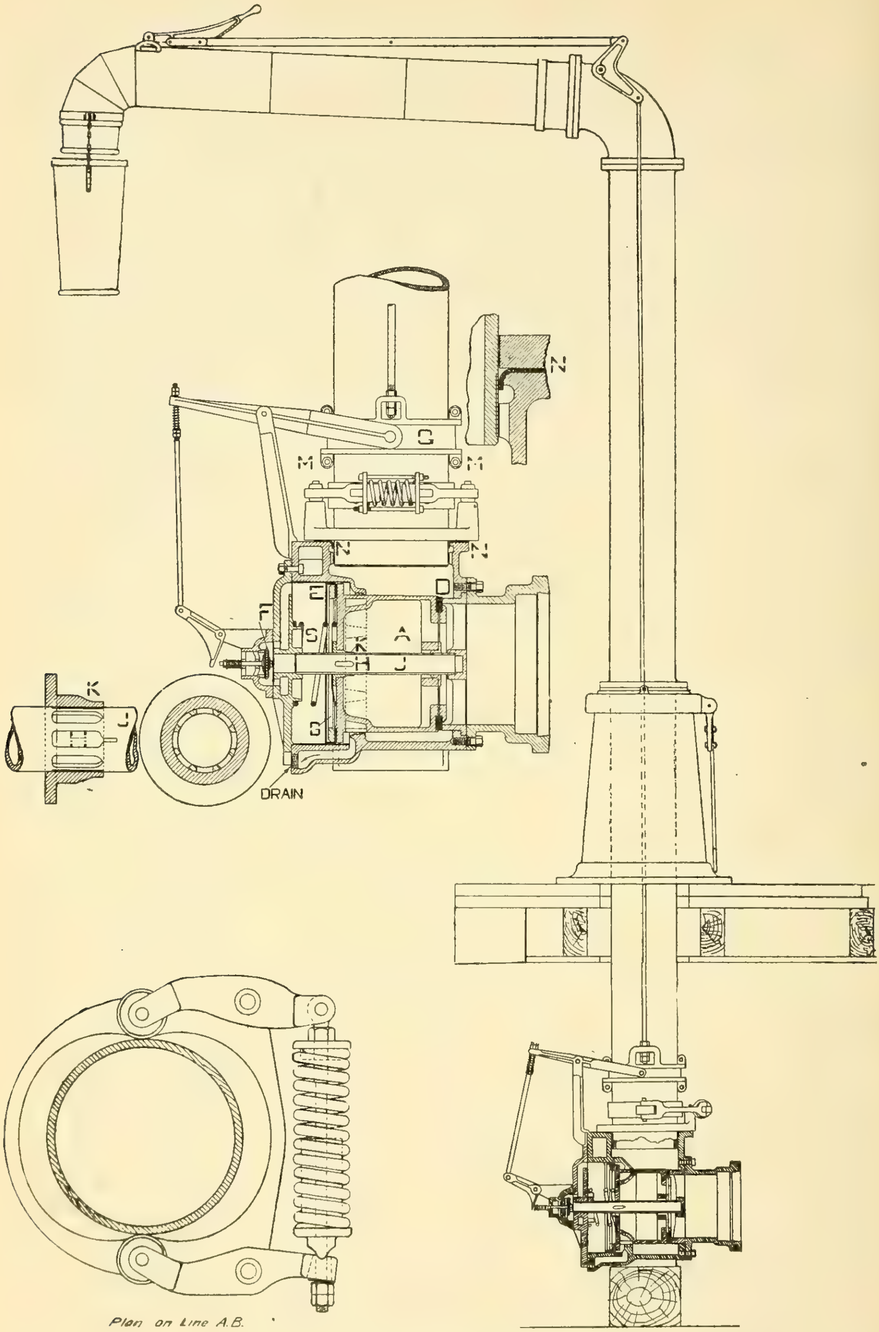

N
C
M
M
N
N
D
E
F
S
K
A
H
J
G
K
J
DRAIN
Plan on Line A.B.

Fig. 16.—Water Column, Type H.

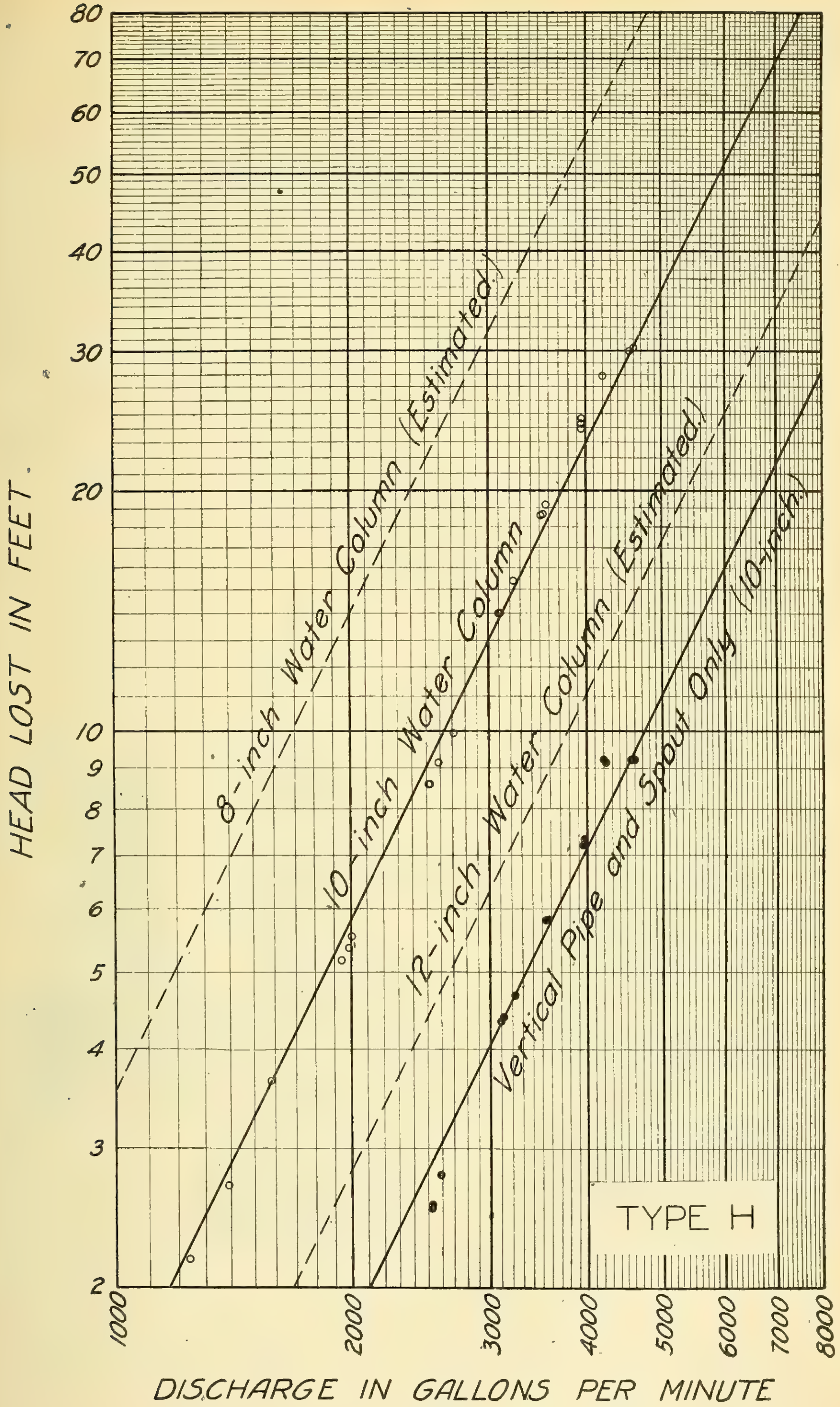


FIG. 17.—LOSS OF HEAD IN WATER COLUMN, TYPE H.

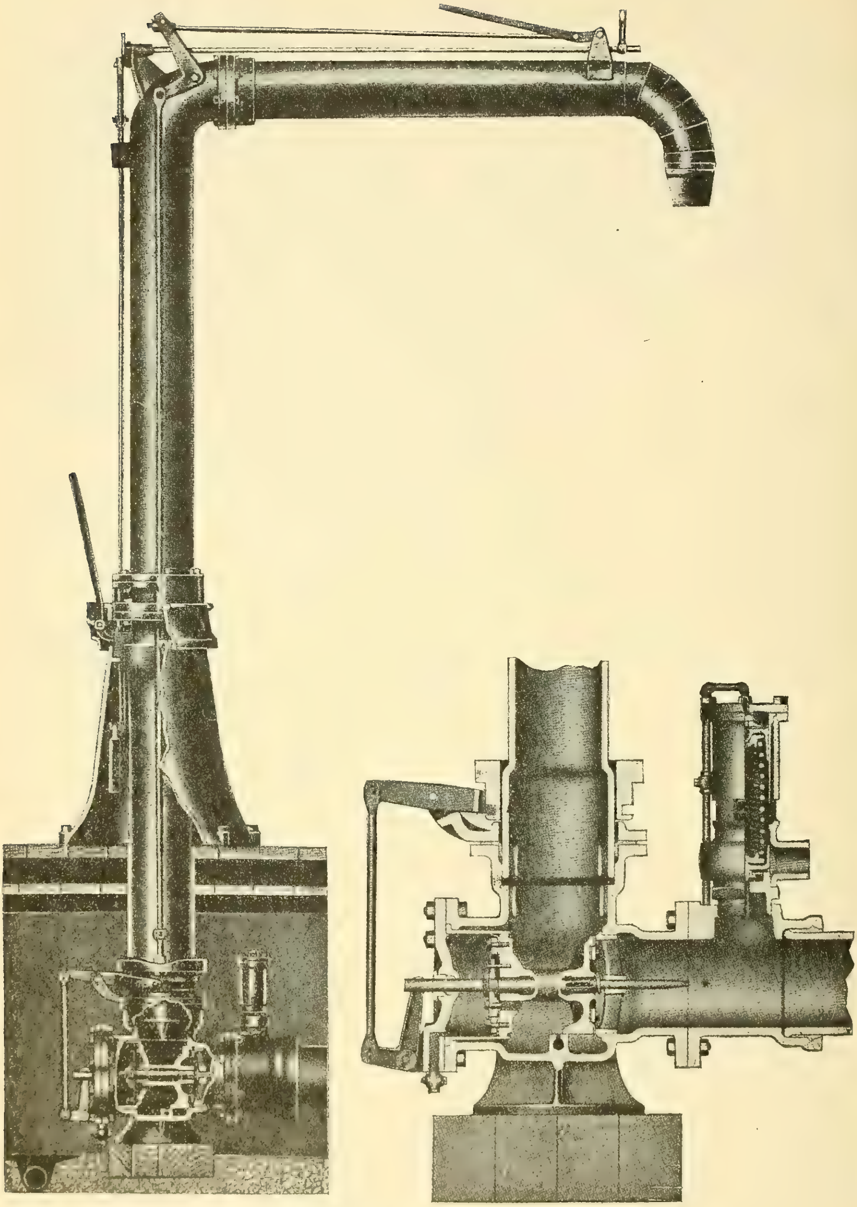


Fig. 18.—Water Column, Type I.

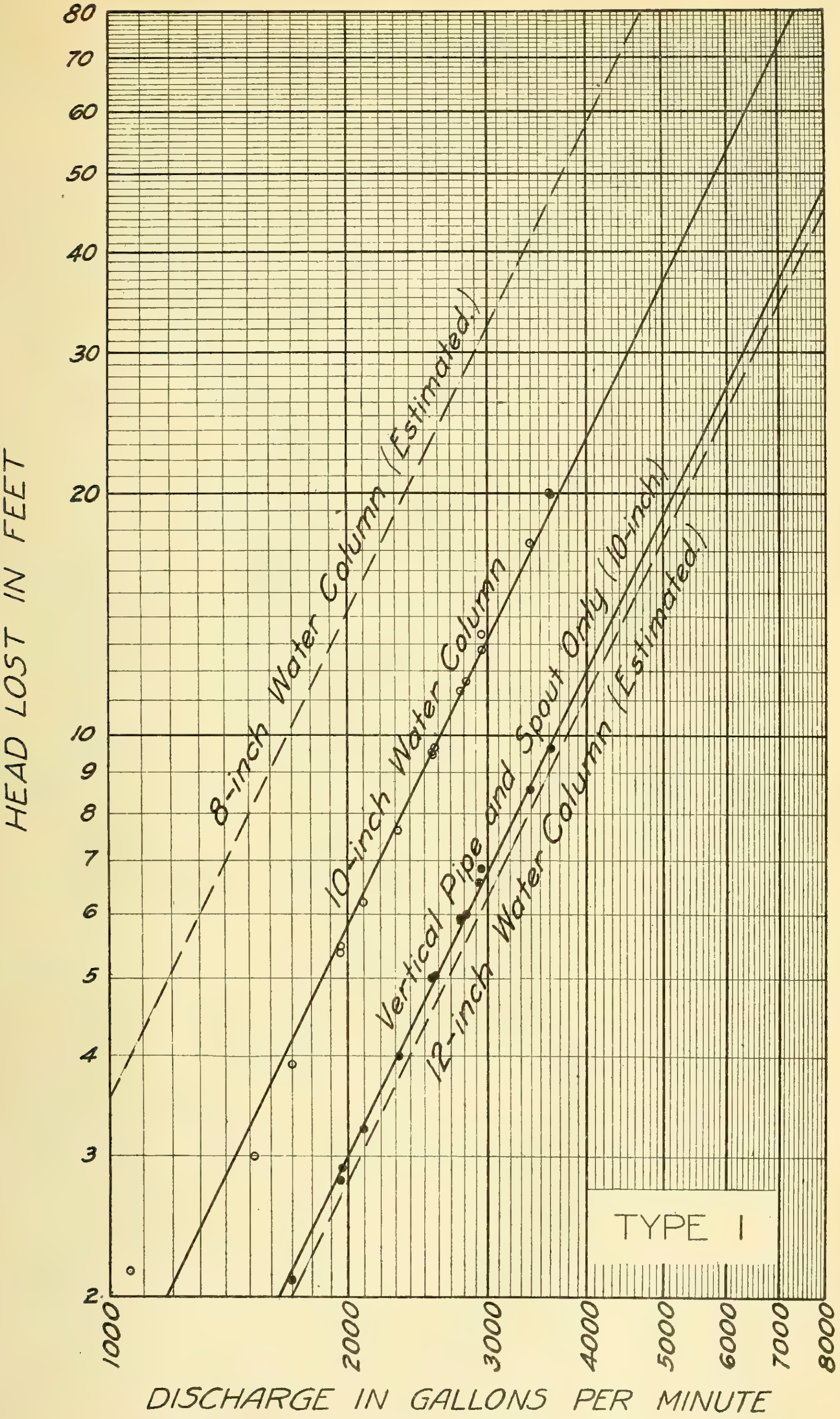


Fig. 19.—Loss of Head in Water Column, Type I.

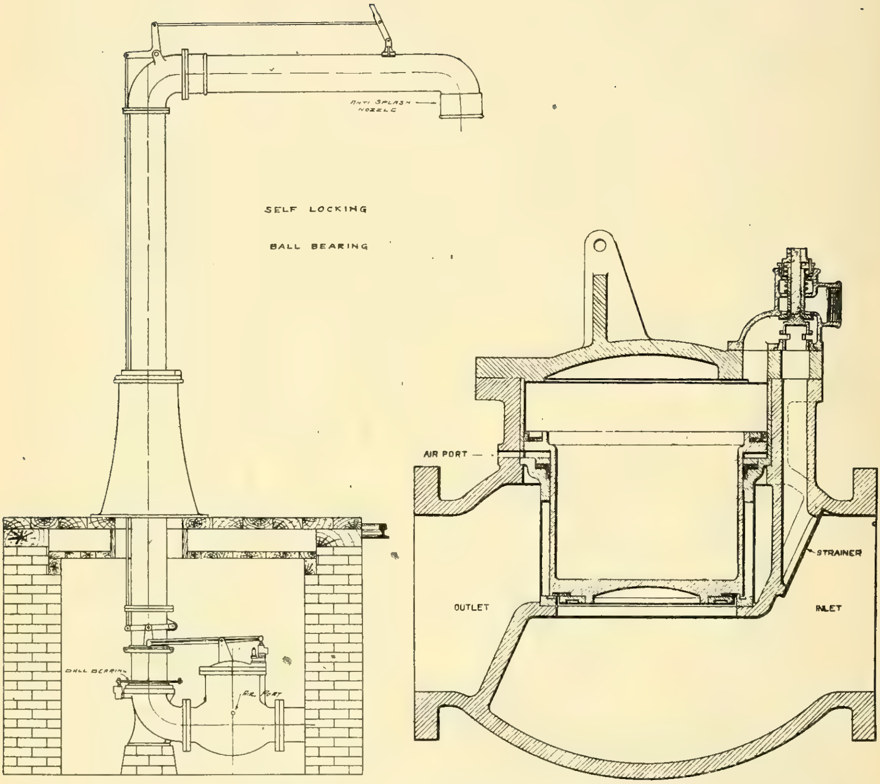

ANTI SPLASH NOZZLE
SELF LOCKING
BALL BEARING
BALL BEARING
AIR PORT
AIR PORT
STRAINER
OUTLET
INLET

FIG. 20.—WATER COLUMN, TYPE J.

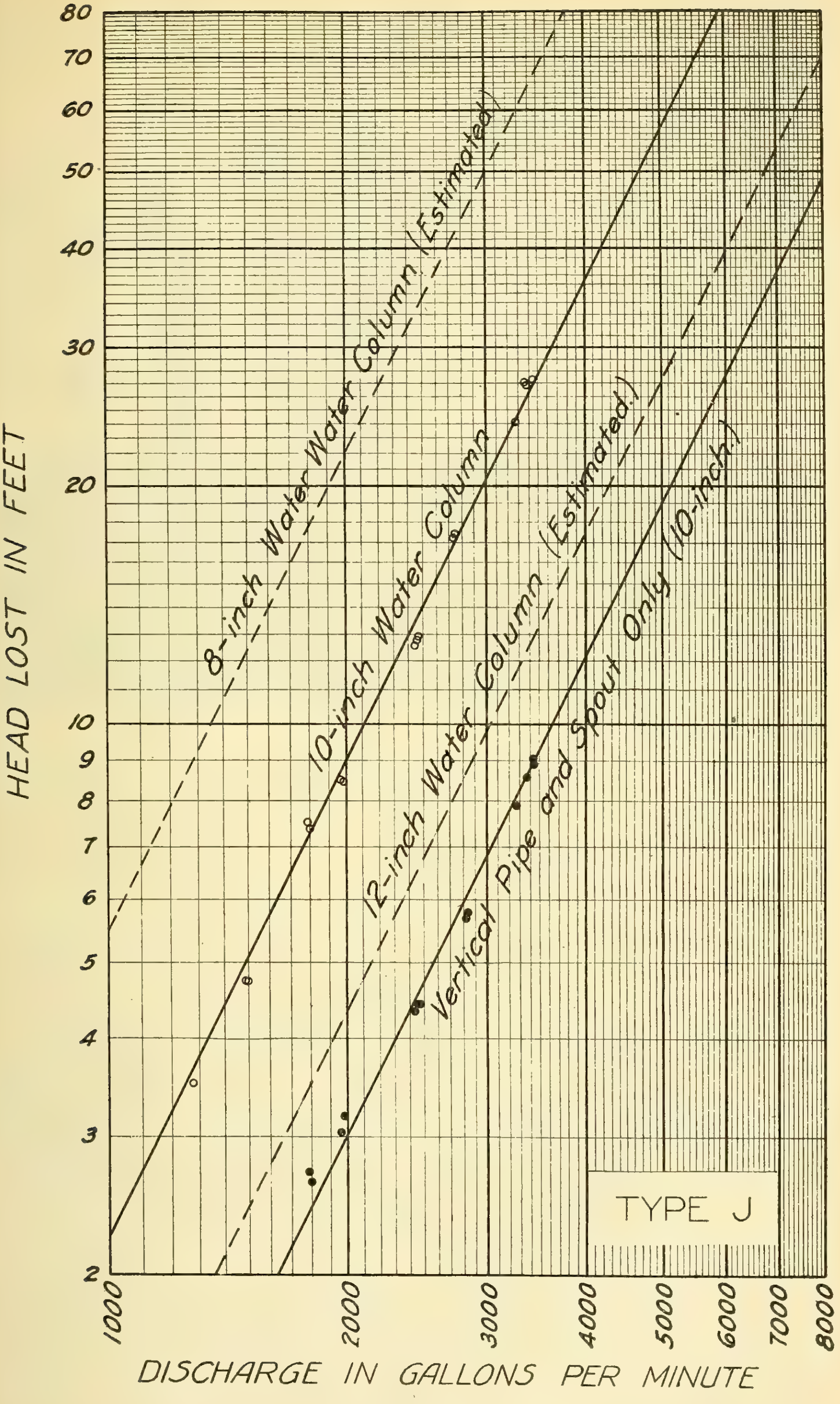


Fig. 21.—Loss of Head in Water Column, Type J.

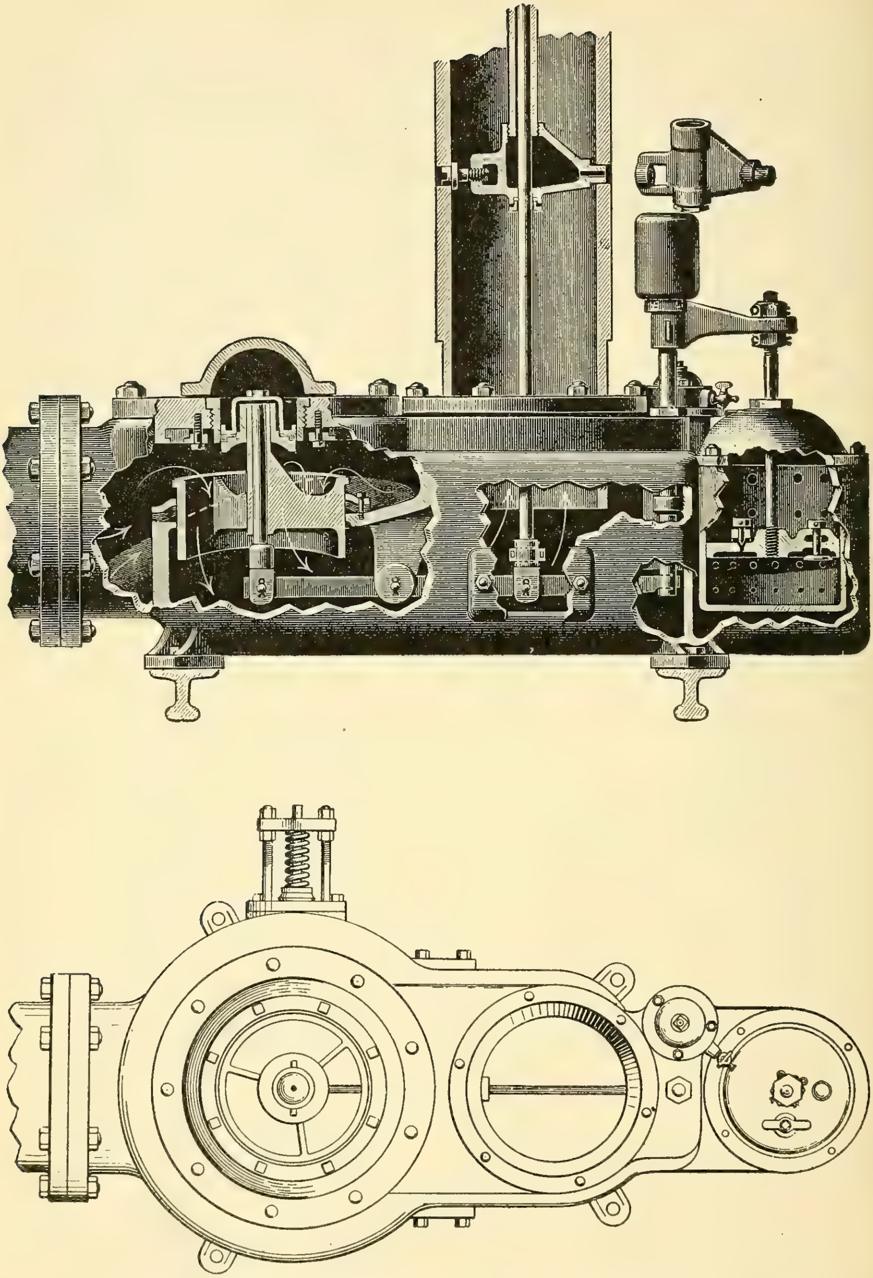


FIG. 22.—DETAILS OF VALVE FOR TYPES A AND B.

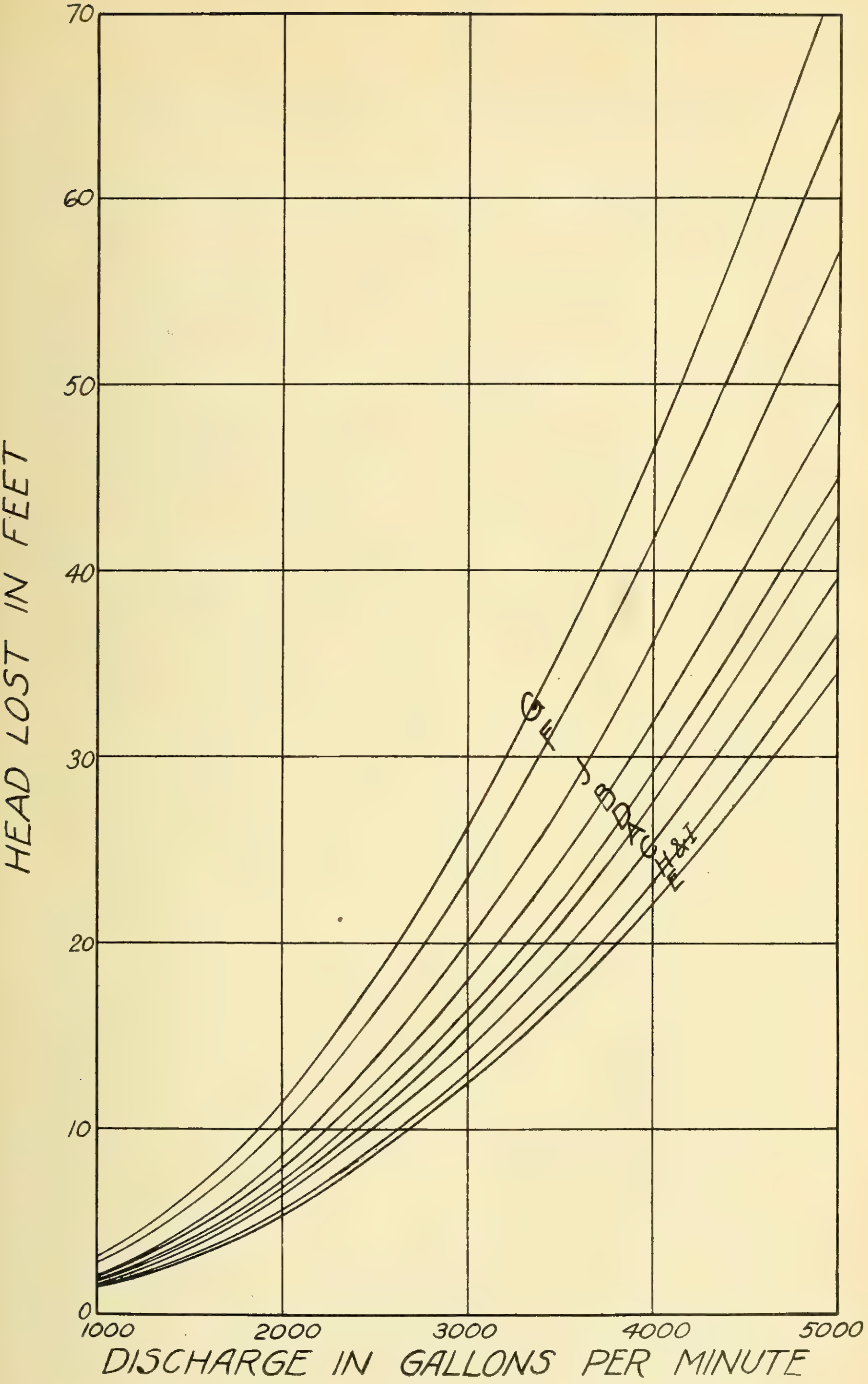


Fig. 23.—Loss of Head in Water Columns, All Types.

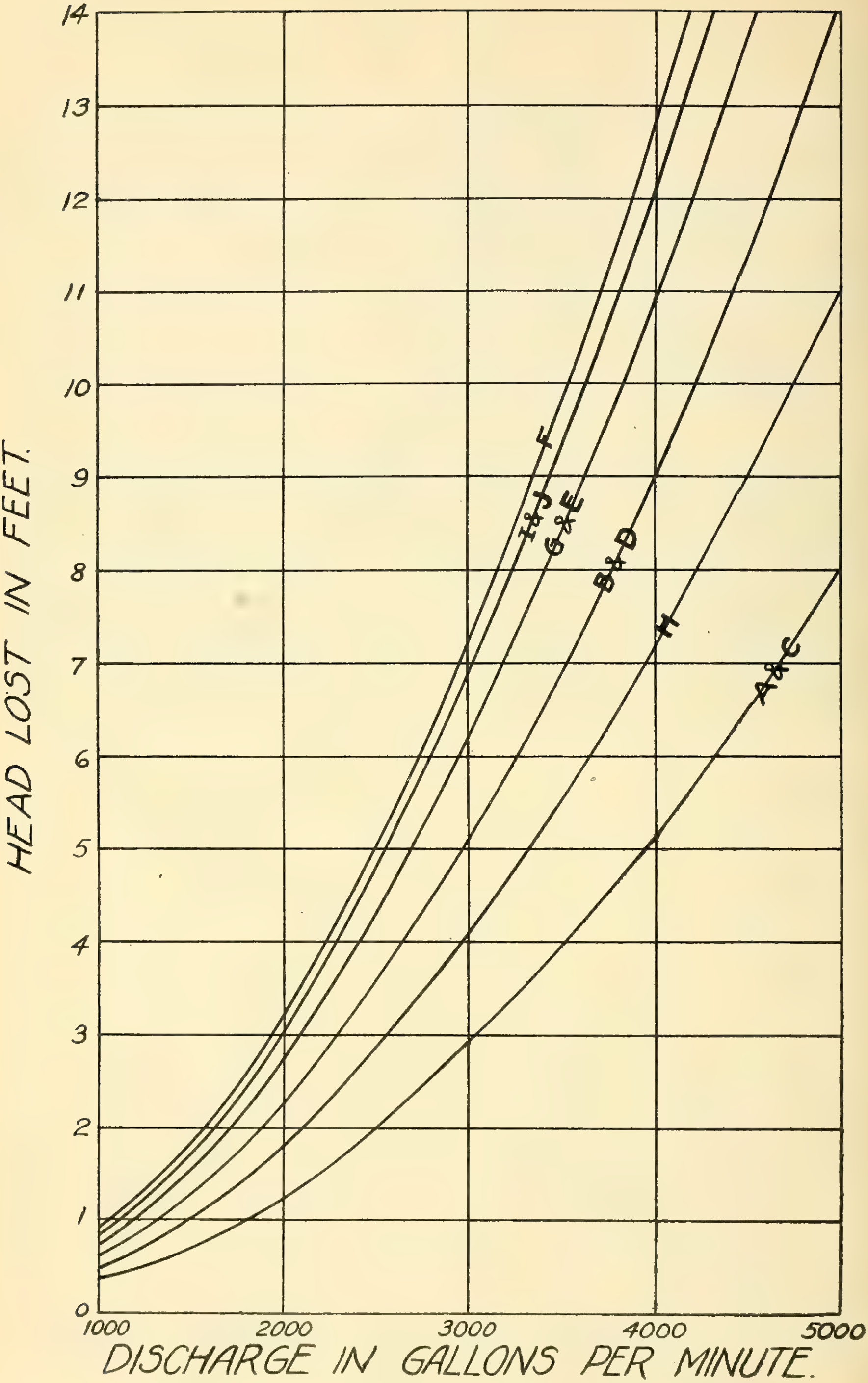
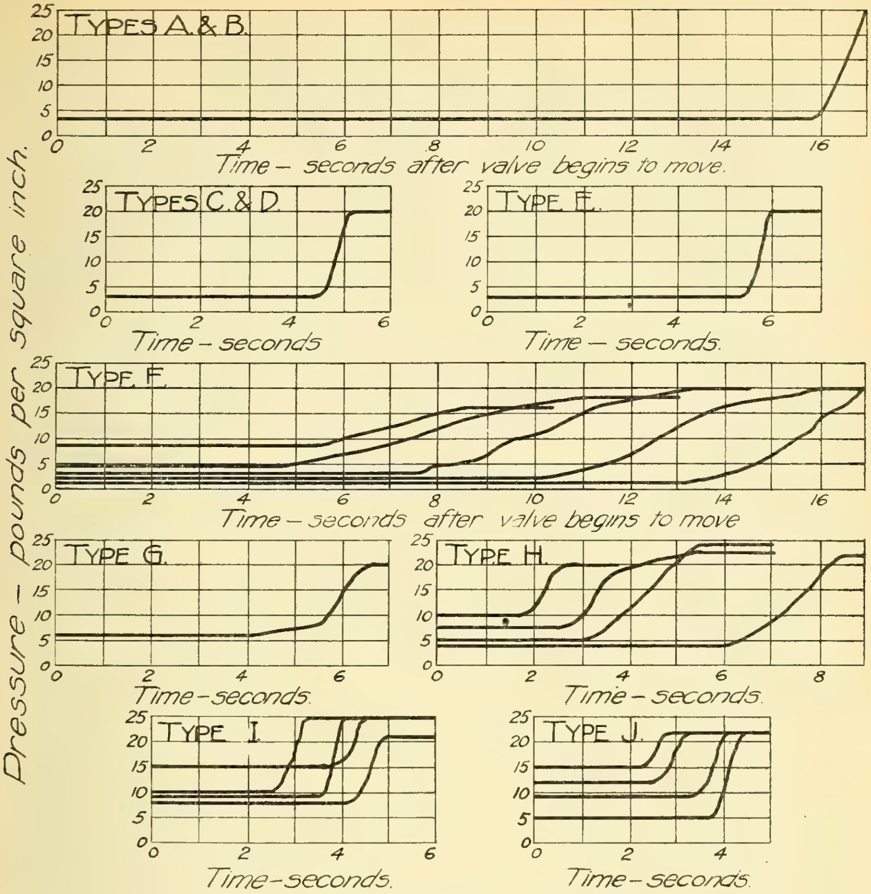
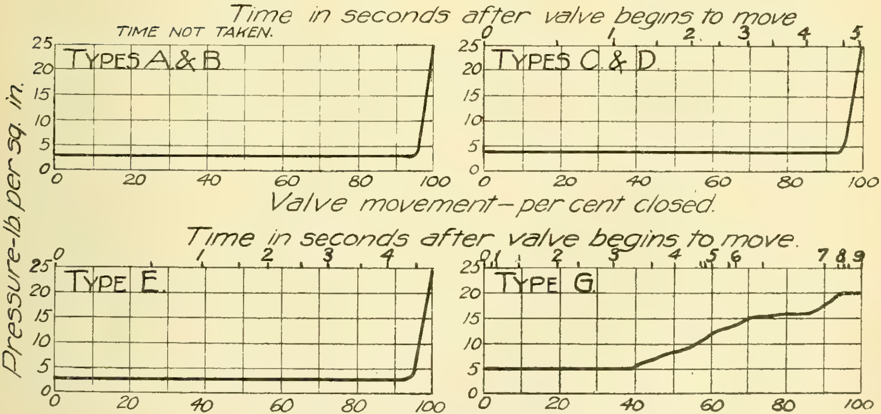


FIG. 24.—HEAD IN RISER AND SPOUT, ALL TYPES.



TIME-PRESSURE DIAGRAMS.



VALVE MOVEMENT-PRESSURE DIAGRAMS.

FIG. 25.—TIME PRESSURE AND VALVE MOVEMENT PRESSURE DIAGRAMS.

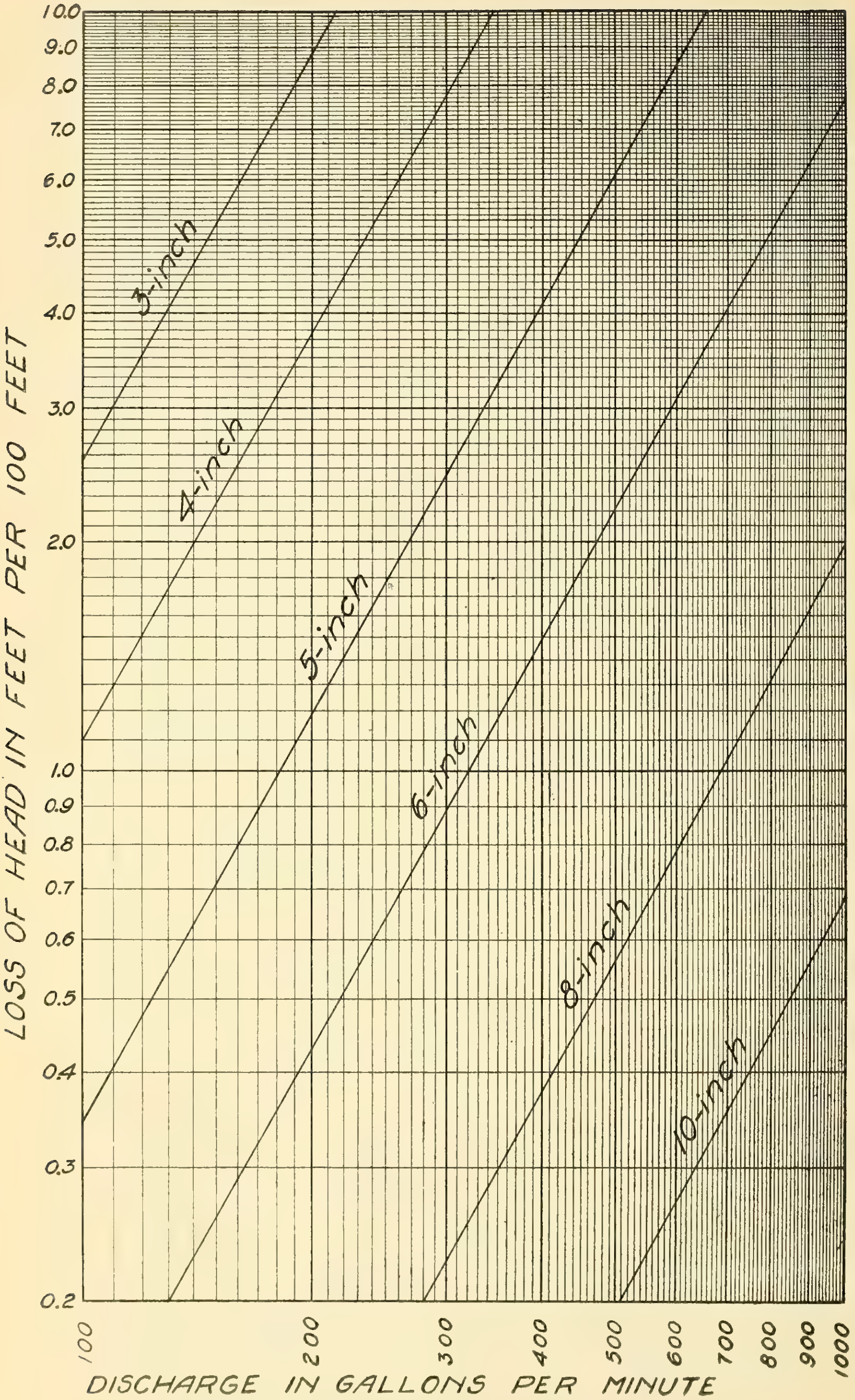


Fig. 26.—Loss of Head in New Straight Pipe.

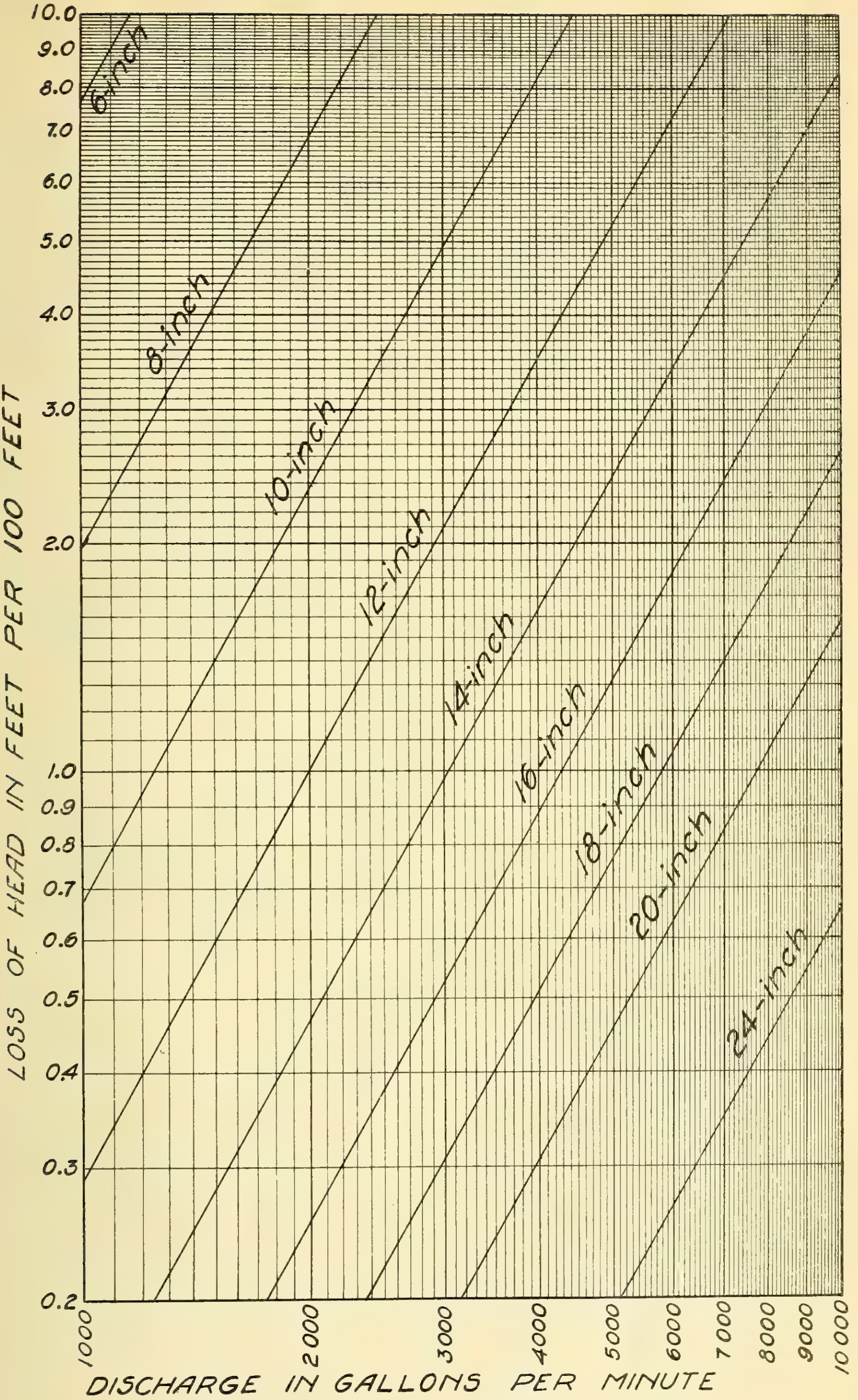


FIG. 27.—LOSS OF HEAD IN NEW STRAIGHT PIPE.

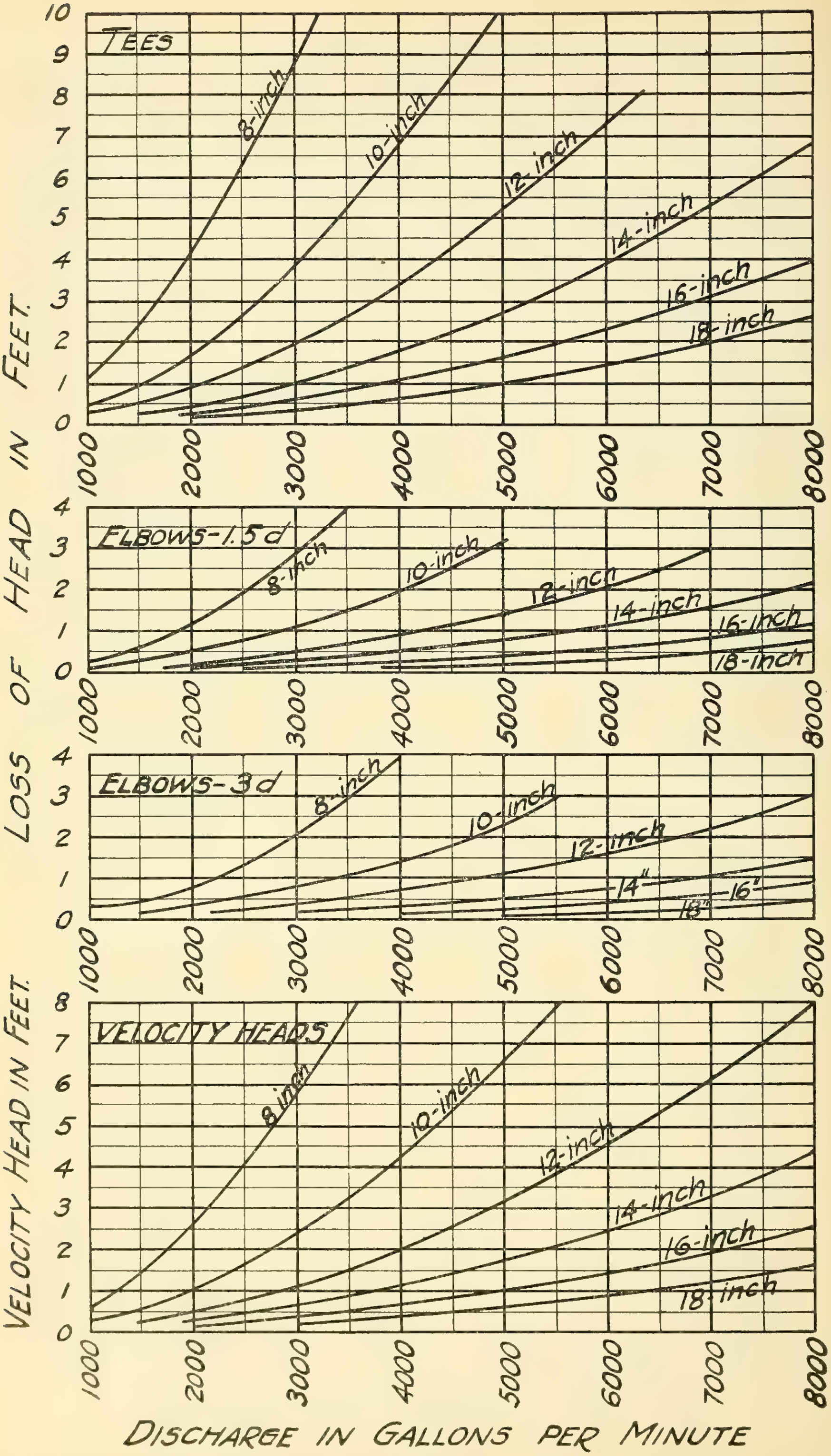


Fig. 28.—Loss of Heads in Elbows and Tees and Values of Velocity Head.

COMMITTEE XIV.

YARDS AND TERMINALS.

*DEFINITIONS.

TERMINALS.

Terminal.—An assemblage of facilities provided by a railway at a terminus or at intermediate points on its line for the purpose of assembling, breaking-up, and relaying trains.

Freight Terminal.—The arrangement of terminal facilities for the handling of freight business.

Passenger Terminal.—The arrangement of terminal facilities for the handling of passenger business.

YARDS.

Yard.—A system of tracks within defined limits provided for making up trains, storing cars and other purposes, over which movements not authorized by time-table or by train-order may be made, subject to prescribed signals and regulations.

Receiving Yard.—A yard for receiving trains.

Separating Yard.—A yard adjoining a receiving yard, in which cars are separated according to district, commodity, or other required order.

Classification Yard.—A yard in which cars are classified or grouped in accordance with requirements.

Departure or Forwarding Yard.—A yard in which cars are assembled in trains for forwarding.

Storage Yard.—A yard in which cars are held awaiting disposition.

Gravity Yard.—A yard in which the classification of cars is accomplished by gravity.

Assisting Grade.—The inclination given to tracks of a yard to facilitate the movement of cars.

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* Adopted, Vol. 2, 1901, pp. 39, 40, 46-59; Vol. 4, 1903, p. 349; Vol. 5, 1904, pp. 221, 224-226; Vol. 6, 1905, pp. 568-570, 575, 592; Vol. 7, 1906, pp. 153-155; Vol. 11, Part 2, 1910, pp. 1257, 1258, 1309, 1310; Vol. 12, Part 1, 1911.

Poling Yard.—A yard in which the movement of cars is accomplished by the use of a pole operated by an engine on an adjacent parallel track.

Summit or Hump Yard.—A yard in which the movement of cars is accomplished by pushing them over a summit, beyond which they run by gravity.

TRACKS.

Body Track.—Each of the parallel tracks of a yard, upon which cars are switched or stored.

Ladder Track.—A track connecting successively the body tracks of a yard.

Lead Track.—An extended track connecting either end of a yard with the main track.

Drill Track.—A track connecting with the ladder track and used for movements in yard switching.

Running Track.—A track reserved for movements through a yard.

Crossover Track.—A track connecting two adjacent tracks.

Relief Track.—An extended siding long enough to allow an inferior train to continue running.

Stub Track.—A track connected with another at one end only.

Spur Track.—A stub track of indefinite length diverging from main line.

House Track.—A track alongside of (or entering) a freight house, and used for cars receiving or delivering freight at the house.

Switching District.—That portion of a railway at a large terminal into which cars are moved, and from which they are distributed to the various sidetracks and spurs to freight houses and manufacturing establishments served from this district by yard or switching engines.

Industrial Track.—A track serving one or more industries.

Team Track.—A track where freight is transferred direct between cars and wagons.

Note.—In a typical yard there will be several tracks devoted to special purposes, varying with local conditions. These will include caboose tracks, scale tracks, coaling tracks, ashpit tracks, bad-order tracks, repair tracks, icing tracks, feed tracks, stock tracks, transfer tracks, sand tracks, depressed tracks, etc.

Rail and Water Terminal.—A terminal where freight is transferred between railway cars and boats.

Wye.—A triangular arrangement of tracks used for turning engines, cars or trains.

Transfer Slip.—A protected landing place for transfer boats with adjustable apron or bridge for connecting the tracks on the land with those on the transfer boats.

Incline.—An inclined track (or tracks) at a protected landing place, with adjustable apron and cable for connecting to the tracks on a transfer boat.

Siding.—A track auxiliary to main track for meeting or passing trains, limited to the distance between two adjacent telegraph stations.

PIERS.

Lighterage Pier.—An open or covered pier at which freight is transferred directly between cars and boats.

Export Pier.—A pier at which freight is unloaded and stored, mainly for shipment on ocean or coasting vessels.

Station Pier.—A pier having no rail connections, where freight is received and delivered by transfer boats.

Coal Pier.—An open pier where coal is transferred from cars to vessels or barges.

*GENERAL REQUIREMENTS OF YARDS AND TERMINALS.

Body Tracks.—Under ordinary conditions body tracks should be spaced 12 ft. to 13 ft. c. to c., and where they are parallel to main track or other important running track, the first body track should be spaced not less than 15 ft. c. to c. from such main or other important track.

Ladder Tracks.—These should be spaced not less than 15 ft. c. to c. from any parallel track. Frogs of greater angle than No. 8 should not be generally used, and the angle between the ladder track and body tracks will be governed by the distance on ladder track required for a turnout.

Lead Tracks.—To facilitate train movements the connections of these tracks with the main track should be interlocked, and to facilitate and protect train movements means of direct communication should be established.

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* Adopted, Vol. 2, 1901, pp. 43-45; Vol. 3, 1902, pp. 267, 268, 280-288; Vol. 4, 1903, pp. 370-380; Vol. 5, 1904, pp. 182-184, 221-224; Vol. 6, 1905, pp. 570-574, 583, 592-594; Vol. 11, Part 2, 1910, pp. 1258, 1259, 1309; Vol. 12, Part 1, 1911.

Drill Tracks.—Drill tracks should be so located as to cause least possible interference with other movements.

Running Tracks.—Running tracks should be provided for movements in either direction to enable yard engines to pass freely from one portion of the yard to the other, also to enable road and yard engines to pass to and from the engine house and other points where facilities are provided.

Crossover Tracks.—Crossovers should be located at most convenient points, and where they will least interfere with regular movements.

Caboose Tracks.—Where conditions permit, caboose tracks should be so located that cabooses can be placed on, and removed from them in the order of their arrival, and should be so constructed that cabooses can be dropped by gravity onto the rear of departing trains.

Scale Tracks.—Scale tracks should be so located that weighing can be done with least delay; and where many cars are to be weighed, they should pass over the scale by gravity and be weighed while in motion.

Coaling, Ashpit, Sand and Engine Tracks.—These tracks should be located on the route leading to and from the engine house and should provide sufficient storage for the reception of engines by the hostler. They should be so arranged (1) that water, coal and sand can be taken and ashes disposed of in convenient rotation, and (2) that switching engines may clean fires, take coal, water and sand and pass around waiting engines.

Bad-Order Tracks.—Where cars are classified, one or more classification tracks, easy of access, should be provided for setting off cars in bad order, from which they may be readily removed to the repair tracks.

Repair Tracks.—These tracks should have a maximum capacity of about 15 cars each, spaced alternately 16 ft. and 24 ft. c. to c. and be connected conveniently to bad-order tracks.

Icing Tracks.—Icing tracks should be so located that the work of shifting out, icing and classifying cars for movement can be performed in least time.

Yard.—If possible to so arrange, the main tracks of both single and double track roads should be located on the outside of yard, and engine house, coaling station, etc., should be centrally located.

Coach Cleaning Yard.—The coach cleaning yard should be located near the terminal station, and tracks should be of sufficient length to hold full trains, with a car cleaners' repair and supply building adjacent thereto.

Inbound Freight House.—Inbound freight house should be of such width as will furnish a reasonable amount of floor space for holding freight (50 ft. is a good average width). Usually not more than two tracks are needed, and the side toward the tracks should be provided with a platform and should be fitted with doors moving vertically between the posts to avoid the necessity for spotting cars.

Outbound Freight House.—The outbound freight house should be narrow (25 ft.) is a good average width) and not more than four tracks should be provided. The side toward the tracks should have a platform, and should be fitted with doors moving vertically between the posts.

Where a great number of cars are required, the average trucking distance will generally be least and trucking through cars will be avoided if the freight house is built at right angles to and at the back ends of a series of tracks built in pairs with covered platforms between.

Roadways.—Where the freight house is on one side and a wall on the other, the minimum width of roadway should be 30 ft.; but where a freight house is on one side and a team track or another freight house is on the other, the minimum clear width of roadway should be 40 ft.

Transfer Station.—A transfer station should be located at a point where traffic is concentrated, and where a necessity exists for consolidating freight into a less number of cars for movement to a certain destination, or for separating and reloading freight into a greater number of cars or into system cars for further movement to final delivery.

Yard at Rail and Water Terminals.—The tracks should be so arranged that as trains arrive the cars can be promptly classified and grouped for delivery without interference with other movements.

Piers.—At rail and water terminals the piers should be designed with a view to the most efficient, rapid and economical handling of the business, and with a view to its future development. Care must be taken to give due weight to the special conditions and features of location, traffic, etc., which exist in every case, and which render it impossible to lay down any but the most general rules.

In every individual case the length, width, number of tracks, width of platforms, details of construction and width of waterway between adjacent piers must be adjusted to best meet conditions as to shape and area of site as well as its relation to its approaches from both land and water, the character and volume of business and the manner in which it is to be handled.

Covered Lighterage Pier.—When conditions will permit, present practice will generally suggest a length of approximately 600 ft. with two depressed tracks. If the business to be handled over the pier is expected to move quickly the width should be no greater than is necessary to provide temporary storage and shelter for the goods during ordinary detentions while waiting for cars or lighters, preferably about 100 ft. If the movement is expected to be slow and it is necessary to provide storage while waiting for cars or vessels, or for assorting, classifying, inspecting or sale of goods, the width should be increased, but generally not beyond a width of 125 to 160 ft. If the movement is not expected to have a special character, or a mixed business is to be provided for, a compromise width of 125 ft. is suggested. The space between the shed and the outer edge of the pier should be not less than two feet, and the clear width of waterway between piers should be, if possible, not less than four times the width of the largest vessel to be handled.

Open Lighterage Pier.—This should, if possible, have a length of about 600 ft. and the width, number of tracks and the appliances for handling traffic should be adjusted to the particular use to which the pier is to be applied. On long piers, crossovers may be necessary.

For ordinary coarse freight in bulk, such as iron ore, stone, timber and similar products, the width should be from 50 to 80 ft., and there should be four tracks, with crossovers, to facilitate the handling of cars and avoid delay in transferring to or from vessels. If the business is light, or consists principally of heavy or costly products, such as cut stone, machinery, or miscellaneous freight not requiring shelter, a narrow pier of about 35 ft. in width, with two tracks only, is recommended.

Export and Storage Pier.—This should be designed with special reference to the character of the commodities to be handled; whether quick movement is expected or the goods are to be held some time in storage for the accumulation of full cargoes, or for inspection or classification. There should be two tracks in a depressed pit on the pier level, which, on long piers, should be properly connected by crossovers at convenient intervals to facilitate the movement of cars. On very wide piers additional tracks on the pier level are desirable under certain conditions. Where the water front is limited or very valuable and the conditions, volume and character of business warrant, pier sheds of two or more stories, with platform or barrel elevators and bag or barrel chutes are used. Under certain conditions additional tracks in the second story may prove more advantageous than elevators. The length should be sufficient to properly accommodate either one or two vessels on each side at the same time, or approximately 600 to 1,400 ft. The width must be determined by the space available and the business to be handled. If quick moving, a width of 125 to 150 ft. is recommended. If slow moving and large accumulations must be received and stored, the width may be extended, if space permits, to 300 or even 400 ft., but excessive width is not recommended on account of the consequent increase in cost of handling. The space between shed and face of pier should not be less than three nor more than six feet, and the clear waterway between piers should be, if possible, not less than four times the width of the largest vessels to be handled.

COAL PIER.—This should be an open pier, and where coal is to be delivered to vessels through pockets and chutes in the ordinary way, the pier should be high enough to allow coal from drop-bottom cars to be loaded by gravity into vessels or barges. It should have three or more tracks, the outside tracks for loaded cars and the inside one on an incline to return the empty cars to the yard by gravity. The length depends upon the grade necessary to reach the desired elevation, the length of the vessels to be coaled and the number of cars it is desired to unload at one time. Adjacent piers should be sufficiently distant to accommodate the class of service, which will depend on the length of the pier and the size of the water craft to be accommodated. Where coal cars are dumped by machinery which elevates and tilts the cars a high pier is not necessary, and it may be of any convenient height.

STATION PIER.—A city station pier served by car floats should be approximately 600 ft. long and 125 ft. wide, with a depressed driveway in the center 35 ft. wide. It should be a closed pier, with 3-ft. platform outside. Adjacent parallel piers should be, if possible, 200 ft. apart in the clear. Along the water street should be a bulkhead, approximately 55 ft. wide, with two-story building, the upper floor being for offices, fruit auction room, etc.

GRAIN ELEVATORS.—If conditions permit, grain elevators should be so located that cars may be put in at one end and taken out at the other, and without interference with other yard movements. Where this cannot be done, the tracks should be so arranged that the work of placing and removing cars may be done without serious interference with the operation of the elevator or delay to other shifting.

*CAR CAPACITY OF FREIGHT TRACKS.

It is recommended that 42 ft. per car be allowed in rating the car capacity of freight tracks.

(1) Freight car repair yards should be composed of short tracks of about fifteen cars capacity, arranged in pairs; each pair should be spaced 16 ft. c. to c. of tracks, and the pairs should be spaced 40 ft. c. to c. of pairs.

(2) A material supply track should be placed in the space between each pair of tracks.

(3) In computing working capacity of repair tracks 50 ft. should be allowed for each car.

(4) The yard should be equipped with air and water pipes, and outlets furnished with air hose should be provided at intervals of 50 ft. for testing the brakes on cars.

(5) Tracks on which heavy repairs to freight cars are made should be under cover, and overhead traveling cranes should be provided for heavy lifting.

† TEAM DELIVERY YARDS.

(1) Team delivery yards should be located convenient to the freight house so that the receipt and shipment of freight may be easily under control of the freight agent's force.

(2) The tracks should be stub tracks arranged in pairs spaced 12 ft. c. to c., and if conditions permit the pairs should be spaced not less than 52 ft. c. to c. of pairs, or 30 ft. in clear. For convenience in handling, the track should not exceed 20 cars capacity each.

(3) If possible the yard should be provided with a power-driven crane for handling heavy freight.

(4) Ingress and egress for teams should be provided at each end of each teamway, if possible.

(5) Wagon scales should be installed at the most convenient place near the entrance to the driveway, and a track scale should be placed at the most convenient location for weighing cars when entering or leaving the yard.

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[*] Adopted, Vol. 6, 1905, pp. 579, 594; Vol. 11, Part 2, 1910, pp. 1262, 1263, 1309.

[†] Adopted, Vol. 7, 1906, pp. 155, 156, 171; Vol. 11, Part 2, 1910, pp. 1263, 1309.

* HUMP YARDS.

(1) Hump yards should consist of receiving, classification and departure tracks, in consecutive order.

(2) A hump yard is a desirable form of yard for receiving, classifying and making up trains, because cars can be handled through it faster and at less cost than through any other form of yard.

(3) Receiving tracks should be of sufficient length to hold maximum trains of the various classes handled.

(4) Receiving tracks should be sufficient in number to hold a number of trains arriving in quick succession. The number will depend on the amount and character of traffic handled, and upon the relative location of the yard with respect to the other yards and connections.

(5) If it is possible, the grades of the receiving tracks should be such that one engine can push the maximum train over the hump.

(6) No definite recommendation can be made as to length or number of classification tracks, except that when they are to be used as departure tracks, they should be long enough to hold full trains, and that when conditions permit, there should be as many of them as can be used to advantage to avoid subsequent classification and consequent delay.

(7) Departure tracks should be full train length and of sufficient number to provide ample standing room for trains while being tested for air, and while waiting for engines.

(8) An air-brake testing plant should be provided in the receiving and departure yards, the tracks should be piped, and sufficient outlets furnished with hose to test air brakes on all trains.

(9) To secure the greatest possible efficiency or to so construct a hump that the greatest number of cuts of cars may be classified over it, the steepest part of the grade should be reached in the least available distance after passing the summit, and the grade or fall should provide sufficient momentum to carry all cars to lower ends of classification tracks.

(10) Where cars to be classified are largely empty or light, and the scale is on the hump, grades are recommended for average conditions as follows:

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* Adopted, Vol. 7, 1906, pp. 152, 153, 168-170, 173-179; Vol. 11, Part 2, 1910, pp. 1263, 1264, 1309.

The summit of the hump should be reached from the ascending grade by vertical curves with radius of about 1,500 ft. that raise the grade about one foot in a distance of 60 ft. The curve over the summit to be continued on the descending grade a distance of about 30 ft. to join a grade not exceeding 2 per cent. for a distance not exceeding 60 ft.; thence descending by a vertical curve with a radius of about 2,000 ft., a distance of 40 ft.; thence descending on a grade of 4 per cent., a distance of 50 ft.; thence descending by a vertical curve with radius of about 5,000 ft., a distance of about 155 ft., to join a grade of 1 per cent. at the heads of the ladder tracks; thence down through ladder tracks and turnouts, 1 per cent.; thence down through classification tracks, 0.5 per cent.

(11) Where cars to be classified are largely heavy or loaded, and the scale is on the hump, the same grades are recommended for use over the hump as for light cars, but as the proportion of light cars diminishes the length of the grade of 4 per cent. may be reduced.

It is recommended, however, that the length of the 4 per cent. grade be at least 25 ft.; that the grade of ladder tracks be at least 0.8 per cent., and the grade of classification tracks be at least 0.4 per cent., where conditions permit.

(12) Where traffic or climatic conditions require, the summit of a hump may be made higher in the winter and restored when the increased height is not needed.

(13) When required by traffic conditions, a track scale not exceeding 60 ft. in length should be located at such a distance from the summit of the hump that when cars to be weighed reach the scale they will be properly spaced from following cars and will be running slowly enough to easily secure correct weights. The grade over the scale should not exceed 2 per cent.

(14) For average conditions it is recommended that No. 8 frog be the sharpest used in classification yards.

*YARD LIGHTING.

(1) For yard lighting the use of arc lamps of 2,000 candlepower is recommended.

(2) For lighting hump and ladder tracks, the lamps should be spaced 140 to 150 ft. apart and hung 28 ft. (or more) above the tracks.

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* Adopted, Vol. 9, 1908, pp. 541, 584; Vol. 11, Part 2, 1910, pp. 1264, 1309.

(3) For lighting body tracks, the spacing should be such that cars will be clearly visible.

* FREIGHT TRANSFER STATIONS.

(1) Freight transfer stations should be located at points where traffic converges or diverges, or both, and where necessity exists for its consolidation or separation.

(2) The installation should provide for the greatest possible economy of operation, both as to time and cost of handling.

(3) Where fixed platforms are used, they should be covered, and it is recommended that the width under ordinary conditions be not more than 24 ft., and that the tracks on either side be built in pairs. If greater facilities are required, additional platforms 8 ft. in width may be provided outside of the first two tracks and additional tracks placed outside of them. The width of these additional platforms may be 8 ft., if without roofs, or 12 ft. if covered by roofs, supported by a line of posts in the middle.

(4) Where large amounts of freight are to be transferred, the use of power-driven covered traveling platforms, instead of fixed platforms, is recommended.

† PASSENGER TERMINAL STATIONS.

(1) To avoid excessive cost in providing passenger terminal facilities largely in excess of ordinary requirements, it is imperative that provision be made for economical, efficient and practically continuous operation of the terminal during the periods of greatest activity which may reasonably be expected within a period of, say, twenty years. To this end, the track layout must be designed to permit incoming and outgoing movements to be made at the same time, without interference, as far as it is possible to arrange this.

(2) At passenger terminals where large quantities of baggage and express must be handled, and it does not appear expedient to provide intermediate platforms to be used exclusively for this service, it is recommended that (where conditions permit), baggage and express be received, delivered and handled below the train floor, and raised and lowered by elevators, conveniently located, to avoid interference with the movement of passengers.

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* Adopted, Vol. 7, 1906, pp. 155, 170; Vol. 11, Part 2, 1910, pp. 1264, 1265, 1309.

† Adopted, Vol. 12, Part 1, 1911.

COMMITTEE XV.

IRON AND STEEL STRUCTURES.

*CONTRACTING FOR STEEL RAILWAY BRIDGES.

It is recommended that railway companies

(1) Furnish general detailed plans and specifications of structural work to bidders, complete enough to show the exact character of the work; but if such plans cannot be furnished, the alternative to be full specifications, accompanied by outline plans and all information concerning the work.

(2) Invite bids on a pound price basis; and, if desired, alternate bids may be asked for the work, f. o. b. cars, and for the work erected. A lump sum bid is inadmissible unless general detailed plans and specifications are furnished.

(3) Invite bids for as large groups of bridges as can be defined consistently with the first recommendation, but when required to anticipate future requirements, it is not necessary for the railway to submit designs if the nature of the work is known to the bidder by reason of having previously done work for the railway or if standard designs of similar structures are submitted to the bidders.

(4) Erect bridges with their own forces on lines where traffic is to be maintained; but on small railways where suitably organized and equipped forces for such work may not be justified, the large bridges, and in some cases all bridges, may be erected by contract.

(5) Furnish and lay the floor timber in all cases.

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* Adopted, Vol. 7, 1906, pp. 184, 263, 264; Vol. 11, 1910, pp. 115, 160.

*GENERAL SPECIFICATIONS FOR STEEL RAILWAY BRIDGES.

PART FIRST—DESIGN.

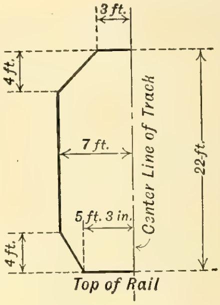
I. GENERAL.

Materials.

1. The material in the superstructure shall be structural steel, except rivets, and as may be otherwise specified.

Clearances.

2. When alinement is on tangent, clearances shall not be less than shown on the diagram; the height of rail shall, in all cases, be assumed as 6 in. The width shall be increased so as to provide the same minimum clearances on curves for a car 80 ft. long, 14 ft. high, and 60 ft. center to center of trucks, allowance being made for curvature and superelevation of rails.



Spacing Trusses.

3. The width center to center of girders and trusses shall in no case be less than one-twentieth of the effective span, nor less than is necessary to prevent overturning under the assumed lateral loading.

Skew Bridges.

4. Ends of deck plate girders and track stringers of skew bridges at abutments shall be square to the track, unless a ballasted floor is used.

Floors.

5. Wooden tie floors shall be secured to the stringers and shall be proportioned to carry the maximum wheel load, with 100 per cent. impact, distributed over three ties, with fiber stress not to exceed 2,000 lbs. per sq. in. Ties shall not be less than 10 ft. in length. They shall be spaced with not more than 6-in. openings; and shall be secured against bunching.

II. LOADS.

Dead Load.

6. The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ lbs. per ft. B.M.; ballast 100 lbs. per cu. ft., reinforced concrete 150 lbs. per cu. ft., and rails and fastenings, 150 lbs. per linear ft. of track.

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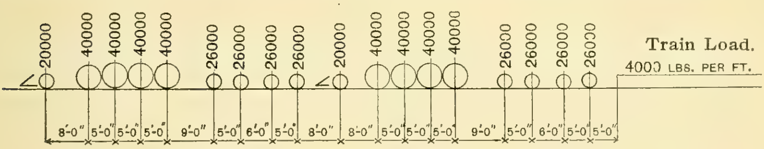
* Adopted, Vol. 4, 1903, pp. 130-137, 141, 142, 253-279; Vol. 5, 1904, pp. 581-583; Vol. 6, 1905, pp. 228-237, 239, 448-455, 481; Vol. 7, 1906, pp. 185-207, 236-263; Vol. 11, Part 1, 1910, pp. 115-125, 160-167.

Live Load.

*7. The live load, for each track, shall consist of two typical engines followed by a uniform load, according to Cooper's series, or a system of loading giving practically equivalent strains. The minimum loading to be Cooper's E-40, as shown in the following diagrams:


20000
40000
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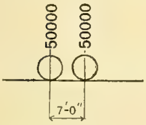
26000
Train Load.
4000 LBS. PER FT.
8'-0"
5'-0"
5'-0"
5'-0"
9'-0"
5'-0"
6'-0"
5'-0"
8'-0"
8'-0"
5'-0"
5'-0"
5'-0"
9'-0"
5'-0"
6'-0"
5'-0"
5'-0"

and  the diagram that gives the larger strains to be used.
50000
50000
7'-0"

Heavier Loading.

*8. Heavier loadings shall be proportional to the above diagrams on the same spacing.

Impact.

9. The dynamic increment of the live load shall be added to the maximum computed live load strains and shall be determined by the formula $I = S\dfrac{300}{L+300}$,

where I = impact or dynamic increment to be added to live-load strains.

S = computed maximum live-load strain.

L = loaded length of track in feet producing the maximum strain in the member. For bridges carrying more than one track, the aggregate length of all tracks producing the strain shall be used.

Impact shall not be added to strains produced by longitudinal, centrifugal and lateral or wind forces.

Lateral Forces.

10. All spans shall be designed for a lateral force on the loaded chord of 200 lbs. per linear foot plus 10 per cent. of the specified train load on one track, and 200 lbs. per linear foot on the unloaded chord; these forces being considered as moving.

Wind Force.

11. Viaduct towers shall be designed for a force of 50 lbs. per sq. ft. on one and one-half times the vertical projection of the structure unloaded; or 30 lbs. per sq. ft. on the same surface plus 400 lbs. per linear ft. of structure applied 7 ft. above the rail for assumed wind force on train when the structure is either fully loaded or loaded on

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*See Addendum, clause (a).

either track with empty cars assumed to weigh 1,200 lbs. per linear ft., whichever gives the larger strain.

Longitudinal Force.

12. Viaduct towers and similar structures shall be designed for a longitudinal force of 20 per cent. of the live load applied at the top of the rail.

13. Structures located on curves shall be designed for the centrifugal force of the live load applied at the top of the high rail. The centrifugal force shall be considered as live load and be derived from the speed in miles per hour given by the expression $60-2\frac{1}{2}D$, where "D"$=$degree of curve.

III. UNIT STRESSES AND PROPORTION OF PARTS.

Unit Stresses.

14. All parts of structures shall be so proportioned that the sum of the maximum stresses produced by the foregoing loads shall not exceed the following amounts in pounds per sq. in., except as modified in paragraphs 22 to 25:

Tension.

15. Axial tension on net section....................16,000

Compression.

16. Axial compression on gross section of columns...$16{,}000-70\frac{l}{r}$

with a maximum of..14,000

where "l" is the length of the member in inches, and "r" is the least radius of gyration in inches.

Direct compression on steel castings......................16,000

Bending.

17. Bending: on extreme fibers of rolled shapes, built sections, girders and steel castings; net section................16,000

on extreme fibers of pins.................................24,000

Shearing.

18. Shearing: shop driven rivets and pins...............12,000

field driven rivets and turned bolts......................10,000

plate girder webs; gross section..........................10,000

Bearing.

19. Bearing: shop driven rivets and pins................24,000

field driven rivets and turned bolts......................20,000

expansion rollers; per linear inch........................ 600 d

where "d" is the diameter of the roller in inches.

on masonry... 600

Limiting Length of Members. 20. The lengths of main compression members shall not exceed 100 times their least radius of gyration, and those for wind and sway bracing 120 times their least radius of gyration.

21. The lengths of riveted tension members in horizontal or inclined positions shall not exceed 200 times their radius of gyration about the horizontal axis. The horizontal projection of the unsupported portion of the member is to be considered as the effective length.

Alternate Stresses. 22. Members subject to alternate stresses of tension and compression shall be proportioned for the stresses giving the largest section. If the alternate stresses occur in succession during the passage of one train, as in stiff counters, each stress shall be increased by 50 per cent. of the smaller. The connections shall in all cases be proportioned for the sum of the stresses.

23. Wherever the live and dead load stresses are of opposite character, only two-thirds of the dead load stresses shall be considered as effective in counteracting the live load stress.

Combined Stresses. 24. Members subject to both axial and bending stresses shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress.

25. For stresses produced by longitudinal and lateral or wind forces combined with those from live and dead loads and centrifugal force, the unit stress may be increased 25 per cent. over those given above; but the section shall not be less than required for live and dead loads and centrifugal force.

Net Section at Rivets. 26. In proportioning tension members the diameter of the rivet holes shall be taken ⅛-in. larger than the nominal diameter of the rivet.

Rivets. 27. In proportioning rivets the nominal diameter of the rivet shall be used.

Net Section at Pins. 28. Pin-connected riveted tension members shall have a net section through the pin-hole at least 25 per cent. in excess of the net section of the body of the member, and the net section back of the pin-hole, parallel with the axis of the member, shall be not less than the net section of the body of the member.

Plate Girders. 29. Plate girders shall be proportioned either by the moment of inertia of their net section; or by assuming that the flanges are concentrated at their centers of gravity; in which case one-eighth of the gross section of the web, if properly spliced, may be used as flange section. The thickness of web plates shall be not less than 1/160 of the unsupported distance between flange angles (see 38).

Compression Flange.

30. The gross section of the compression flanges of plate girders shall not be less than the gross section of the tension flanges; nor shall the stress per sq. in. in the compression flange of any beam or girder exceed $16{,}000-200\frac{l}{b}$, when flange consists of angles only or if cover consists of flat plates, or $16{,}000-150\frac{l}{b}$, if cover consists of a channel section, where l=unsupported distance and b=width of flange.

Flange Rivets.

31. The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the effective depth of the girder at that point combined with any load that is applied directly on the flange. The wheel loads, where the ties rest on the flanges, shall be assumed to be distributed over three ties.

Depth Ratios.

32. Trusses shall preferably have a depth of not less than one-tenth of the span. Plate girders and rolled beams, used as girders, shall preferably have a depth of not less than one-twelfth of the span. If shallower trusses, girders or beams are used, the section shall be increased so that the maximum deflection will not be greater than if the above limiting ratios had not been exceeded.

IV. DETAILS OF DESIGN.

GENERAL REQUIREMENTS.

Open Sections.

33. Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

Pockets.

34. Pockets or depressions which would hold water shall have drain holes, or be filled with waterproof material.

Symmetrical Sections.

35. Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of section, and the neutral axes of intersecting main members of trusses shall meet at a common point.

Counters.

36. Rigid counters are preferred; and where subject to reversal of stress shall preferably have riveted connections to the chords. Adjustable counters shall have open turnbuckles.

Strength of Connections.

37. The strength of connections shall be sufficient to develop the full strength of the member, even though the computed stress is less, the kind of stress to which the member is subjected being considered.

38. The minimum thickness of metal shall be ⅜-in., except for fillers. **Minimum Thickness.**

39. The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than 3 in. for ⅞-in. rivets and 2½ in. for ¾-in. rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be 6 in. for ⅞-in. rivets and 5 in. for ¾-in. rivets. For angles with two gage lines and rivets staggered the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than 12 in. apart in either direction shall be used to hold the plates well together. In tension members, composed of two angles in contact, a pitch of 12 in. will be allowed for riveting the angles together. **Pitch of Rivets.**

40. The minimum distance from the center of any rivet hole to a sheared edge shall be 1½ in. for ⅞-in. rivets and 1¼ in. for ¾-in. rivets, and to a rolled edge 1¼ in. and 1⅛ in., respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 in. **Edge Distance.**

41. The diameter of the rivets in any angle carrying calculated stress shall not exceed one-quarter the width of the leg in which they are driven. In minor parts ⅞-in. rivets may be used in 3-in. angles, and ¾-in. rivets in 2½-in. angles. **Maximum Diameter.**

42. Rivets carrying calculated stress and whose grip exceeds four diameters shall be increased in number at least one per cent. for each additional 1/16-in. of grip. **Long Rivets.**

43. The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets, for a length equal to one and one-half times the maximum width of member. **Pitch at Ends.**

44. In compression members the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between its connections to the flanges. Cover plates shall have a thickness not less than one-fortieth of the distance between rivet lines. **Compression Members.**

45. Flanges of girders and built members without cover plates shall have a minimum thickness of one-twelfth of the width of the outstanding leg. **Minimum Angles.**

46. The open sides of compression members shall be provided with lattice and shall have tie-plates as near each end as practicable. Tie-plates shall be provided at intermediate points where the lattice is inter- **Tie-Plates.**

rupted. In main members the end tie-plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than one-half this distance. Their thickness shall not be less than one-fiftieth of the same distance.

Lattice. 47. The latticing of compression members shall be proportioned to resist the shearing stresses corresponding to the allowance for flexure for uniform load provided in the column formula in paragraph 16 by the term $70\frac{l}{r}$. The minimum width of lattice bars shall be 2½ in. for ⅞-in. rivets, 2¼ in. for ¾-in. rivets, and 2 in. if ⅝-in. rivets are used. The thickness shall not be less than one-fortieth of the distance between end rivets for single lattice, and one-sixtieth for double lattice. Shapes of equivalent strength may be used.

48. Three-fourths-inch rivets shall be used for latticing flanges less than 2½ in. wide, and ¾-in. for flanges from 2½ to 3½ in. wide; ⅞-in. rivets shall be used in flanges 3½ in. and over, and lattice bars with at least two rivets shall be used for flanges over 5 in. wide.

49. The inclination of lattice bars with the axis of the member shall be not less than 45 degrees, and when the distance between rivet lines in the flanges is more than 15 in., if single rivet bar is used, the lattice shall be double and riveted at the intersection.

50. Lattice bars shall be so spaced that the portion of the flange included between their connections shall be as strong as the member as a whole.

Faced Joints. 51. Abutting joints in compression members when faced for bearing shall be spliced on four sides sufficiently to hold the connecting members accurately in place. All other joints in riveted work, whether in tension or compression, shall be fully spliced.

Pin Plates. 52. Pin-holes shall be reinforced by plates where necessary, and at least one plate shall be as wide as the flanges will allow and be on the same side as the angles. They shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross-section of the member.

Forked Ends. 53. Forked ends on compression members will be permitted only where unavoidable; where used, a sufficient number of pin plates shall be provided to make the jaws of twice the sectional area of the member. At least one of these plates shall extend to the far edge of the farthest tie-plate, and the balance to the far edge of the nearest tie-plate, but not less than 6 in. beyond the near edge of the farthest plate.

54. Pins shall be long enough to insure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the threads. **Pins.**

55. Members packed on pins shall be held against lateral movement.

56. Where members are connected by bolts, the turned body of these bolts shall be long enough to extend through the metal. A washer at least ¼-in. thick shall be used under the nut. Bolts shall not be used in place of rivets except by special permission. Heads and nuts shall be hexagonal. **Bolts.**

57. Where splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number theoretically required to the extent of one-third of the number for each intervening plate. **Indirect Splices.**

58. Rivets carrying stress and passing through fillers shall be increased 50 per cent. in number; and the excess rivets, when possible, shall be outside of the connected member. **Fillers.**

59. Provision for expansion to the extent of ⅛-in. for each 10 ft. shall be made for all bridge structures. Efficient means shall be provided to prevent excessive motion at any one point. **Expansion.**

60. Spans of 80 ft. and over resting on masonry shall have turned rollers or rockers at one end; and those of less length shall be arranged to slide on smooth surfaces. These expansion bearings shall be designed to permit motion in one direction only. **Expansion Bearings.**

61. Fixed bearings shall be firmly anchored to the masonry. **Fixed Bearings.**

62. Expansion rollers shall be not less than 6 in. in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned. Segmental rollers shall be geared to the upper and lower plates. **Rollers.**

63. Bolsters or shoes shall be so constructed that the load will be distributed over the entire bearing. Spans of 80 ft. or over shall have hinged bolsters at each end. **Bolsters.**

64. Wall plates may be cast or built up; and shall be so designed as to distribute the load uniformly over the entire bearing. They shall be secured against displacement. **Wall Plates.**

65. Anchor bolts for viaduct towers and similar structures shall be long enough to engage a mass of masonry the weight of which is at least one and one-half times the uplift. **Anchorage.**

Inclined Bearings. 66. Bridges on an inclined grade without pin shoes shall have the sole plates beveled so that the masonry and expansion surfaces may be level.

FLOOR SYSTEMS.

Floor Beams. 67. Floor beams shall preferably be square to the trusses or girders. They shall be riveted directly to the girders or trusses or may be placed on top of deck bridges.

Stringers. 68. Stringers shall preferably be riveted to the webs of all intermediate floor beams by means of connection angles not less than ½-in. in thickness. Shelf angles or other supports provided to support the stringer during erection shall not be considered as carrying any of the reaction.

Stringer Frames. 69. Where end floor beams cannot be used, stringers resting on masonry shall have cross frames near their ends. These frames shall be riveted to girders or truss shoes where practicable.

BRACING.

Rigid Bracing. 70. Lateral, longitudinal and transverse bracing in all structures shall be composed of rigid members.

Portals. 71. Through truss spans shall have riveted portal braces rigidly connected to the end posts and top chords. They shall be as deep as the clearance will allow.

Transverse Bracing. 72. Intermediate transverse frames shall be used at each panel of through spans having vertical truss members where the clearance will permit.

End Bracing. 73. Deck spans shall have transverse bracing at each end proportioned to carry the lateral load to the support.

Laterals. 74. The minimum sized angle to be used in lateral bracing shall be 3½ by 3 by ⅜-in. Not less than three rivets through the end of the angles shall be used at the connection.

75. Lateral bracing shall be far enough below the flange to clear the ties.

Tower Struts. 76. The struts at the foot of viaduct towers shall be strong enough to slide the movable shoes when the track is unloaded.

PLATE GIRDERS.

Camber. 77. If desired, plate girder spans over 50 ft. in length shall be built with camber at a rate of 1/16-in. per 10 ft. of length.

Top Flange Cover. 78. Where flange plates are used, one cover plate of top flange shall extend the whole length of the girder.

Web Stiffeners.

79. There shall be web stiffeners, generally in pairs, over bearings, at points of concentrated loading, and at other points where the thickness of the web is less than 1/60 of the unsupported distance between flange angles. The distance between stiffeners shall not exceed that given by the following formula, with a maximum limit of six feet (and not greater than the clear depth of the web):

$$d = \frac{t}{40}(12{,}000 - s),$$

Where d=clear distance, between stiffeners of flange angles.
t=thickness of web.
s=shear per sq. in.

The stiffeners at ends and at points of concentrated loads shall be proportioned by the formula of paragraph 16, the effective length being assumed as one-half the depth of girders. End stiffeners and those under concentrated loads shall be on fillers and have their outstanding legs as wide as the flange angles will allow and shall fit tightly against them. Intermediate stiffeners may be offset or on fillers, and their outstanding legs shall be not less than one-thirtieth of the depth of girder plus 2 in.

Stays for Top Flanges.

80. Through plate girders shall have their top flanges stayed at each end of every floor beam, or in case of solid floors, at distances not exceeding 12 ft., by knee braces or gusset plates.

TRUSSES.

Camber.

81. Truss spans shall be given a camber by so proportioning the length of the members that the stringers will be straight when the bridge is fully loaded.

Rigid Members.

82. Hip verticals and similar members, and the two end panels of the bottom chords of single track pin-connected trusses shall be rigid.

Eye-Bars.

83. The eye-bars composing a member shall be so arranged that adjacent bars shall not have their surfaces in contact; they shall be as nearly parallel to the axis of the truss as possible, the maximum inclination of any bar being limited to one inch in 16 ft.

Pony Trusses.

84. Pony trusses shall be riveted structures, with double webbed chords, and shall have all web members latticed or otherwise effectively stiffened.

PART SECOND—MATERIALS AND WORKMANSHIP.

V. MATERIAL.

Steel.

85. Steel shall be made by the open-hearth process.

Properties.

86. The chemical and physical properties shall conform to the following limits:

Elements Considered	Structural Steel	Rivet Steel	Steel Castings
Phosphorus, max.... Basic.....	0.04 per cent.	0.04 per cent.	0.05 per cent.
Phosphorus, max.... Acid......	0.06 "	0.04 per cent.	0.08 per cent.
Sulphur, maximum...............	0.05 "	0.04 per cent.	0.05 per cent.
Ultimate tensile strength. Pounds per square inch...........	Desired. 60,000	Desired. 50,000	Not less than 65,000
Elong., min. %, in 8″, Fig. 1.....	$\frac{1{,}500{,}000^{*}}{\text{Ult. tensile str'gth}}$	$\frac{1{,}500{,}000}{\text{Ult. tensile str'gth}}$	15 per cent.
" " "2″, " 2.......	22		
Character of Fracture............	Silky	Silky	Silky or fine granular
Cold Bends without Fracture....	180° flat†	185° flat‡	90° $d = 3t$

* See paragraph 96. † See paragraphs 97, 98, and 99. ‡ See paragraph 100.

The yield point, as indicated by the drop of beam, shall be recorded in the test reports.

87. In order that the ultimate strength of full-sized annealed eyebars may meet the requirements of paragraph 163, the ultimate strength in test specimens may be determined by the manufacturers; all other tests than those for ultimate strength shall conform to the above requirements.

Allowable Variations.

88. If the ultimate strength varies more than 4,000 lbs. from that desired, a retest shall be made on the same gage, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate.

Chemical Analyses.

89. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made from finished material, if called for by the purchaser, in which case an excess of 25 per cent. above the required limits will be permitted.

Specimens.

90. Plate, shape and bar specimens for tensile and bending tests shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig.

1; or with both edges parallel; or they may be turned to a diameter of ¾-in. for a length of at least 9 in., with enlarged ends.

91. Rivet rods shall be tested as rolled.

92. Pin and roller specimens shall be cut from the finished rolled or forged bar, in such manner that the center of the specimen shall be one inch from the surface of the bar. The specimen for tensile test shall be turned to the form shown by Fig. 2. The specimen for bending test shall be one inch by ½-in. in section.

93. For steel castings the number of tests will depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off. Test specimens to be of the form prescribed for pins and rollers.

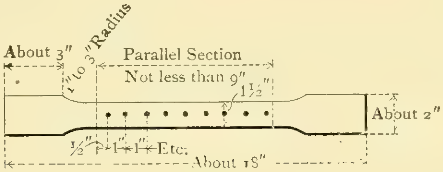

FIG. 1.

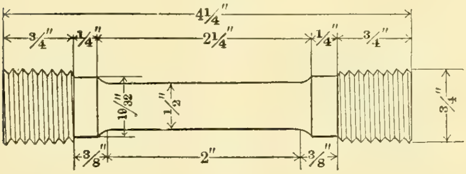

FIG. 2.

94. Rolled steel shall be tested in the condition in which it comes from the rolls. **Specimens of Rolled Steel.**

95. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-in. and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled. **Number of Tests.**

96. A deduction of 1 per cent. will be allowed from the specified percentage for elongation, for each ⅛-in. in thickness above ¾-in. **Modification in Elongation.**

97. Bending tests may be made by pressure or by blows. Plates, shapes and bars less than one inch thick shall bend as called for in paragraph 86. **Bending Tests.**

Thick Material. 98. Full-sized material for eye-bars and other steel one inch thick and over, tested as rolled, shall bend cold 180 degrees around a pin, the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of bend.

Bending Angles. 99. Angles ¾-in. and less in thickness shall open flat, and angles ½-in. and less in thickness shall bend shut, cold, under blows of a hammer, without sign of fracture. This test shall be made only when required by the inspector.

Nicked Bends. 100. Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual break and a fine silky uniform fracture.

Finish. 101. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects, and have a smooth, uniform and workmanlike finish. Plates 36 in. in width and under shall have rolled edges.

Melt Numbers. 102. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag.

Defective Material. 103. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

Variation in Weight. 104. A variation in cross-section or weight of each piece of steel of more than 2½ per cent. from that specified will be sufficient cause for rejection, except in case of sheared plates, which will be covered by the following permissible variations, which are to apply to single plates, when ordered to weight:

105. Plates 12½ lbs. per sq. ft. or heavier:

(a) Up to 100 in. wide, 2½ per cent. above or below the prescribed weight.

(b) One hundred inches wide and over, 5 per cent. above or below.

106. Plates under 12½ lbs. per sq. ft.:

(a) Up to 75 in. wide, 2½ per cent. above or below.

(b) Seventy-five inches and up to 100 in. wide, 5 per cent. above or 3 per cent. below.

(c) One hundred inches wide and over, 10 per cent. above or 3 per cent. below.

107. Plates when ordered to gage will be accepted if they measure not more than 0.01 in. below the ordered thickness.

108. An excess over the nominal weight, corresponding to the dimensions on the order, will be allowed for each plate, if not more than that shown in the following table, one cu. in. of rolled steel being assumed to weigh 0.2833 lb.:

Thickness Ordered	Nominal Weights	Width of Plate			
		Up to 75″	75″ and up to 100″	100″ and up to 115″	Over 115″
¼-inch	10.20 lbs.	10 per cent.	14 per cent.	18 per cent.	....
$\frac{5}{16}$ "	12.75 "	8 "	12 "	16 "	....
⅜ "	15.30 "	7 "	10 "	13 "	17 per cent.
$\frac{7}{16}$ "	17.85 "	6 "	8 "	10 "	13 "
½ "	20.40 "	5 "	7 "	9 "	12 "
$\frac{9}{16}$ "	22.95 "	4½ "	6½ "	8½ "	11 "
⅝ "	25.50 "	4 "	6 "	8 "	10 "
Over ⅝ "	....	3½ "	5 "	6½ "	9 "

Cast-Iron.

109. Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ in. in diameter and 15 in. long. The transverse test shall be made on a supported length of 12 in. with load at middle. The minimum breaking load so applied shall be 2,900 lbs., with a deflection of at least 1/10 in. before rupture.

Wrought-Iron.

110. Wrought-iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1, or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per sq. in., an elongation of at least 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

VI. INSPECTION AND TESTING AT THE MILLS.

Mill Orders

111. The purchaser shall be furnished complete copies of mill orders, and no material shall be rolled nor work done before the purchaser has been notified where the orders have been placed, so that he may arrange for the inspection.

Facilities for Inspection. 112. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine, free of cost.

Access to Mills. 113. When an inspector is furnished by the purchaser to inspect material at the mills, he shall have full access, at all times, to all parts of mills where material to be inspected by him is being manufactured.

VII. WORKMANSHIP.

General. 114. All parts forming a structure shall be built in accordance with approved drawings. The workmanship and finish shall be equal to the best practice in modern bridge works. Material arriving from the mills shall be protected from the weather and shall have clean surfaces before being worked in the shops.

Straightening. 115. Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way.

Finish. 116. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

Size of Rivets. 117. The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet before heating.

Rivet Holes. 118. When general reaming is not required, the diameter of the punch shall not be more than $\frac{1}{16}$-in. greater than the diameter of the rivet; nor the diameter of the die more than $\frac{1}{8}$-in. greater than the diameter of the punch. Material more than $\frac{3}{4}$-in. thick shall be sub-punched and reamed or drilled from the solid.

Punching. 119. Punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be cause for rejection.

Reaming. 120. Where sub-punching and reaming are required, the punch used shall have a diameter not less than $\frac{3}{16}$-in. smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not more than $\frac{1}{16}$-in. larger than the nominal diameter of the rivet. (See 135.)

Reaming after Assembling. 121. *[When general reaming is required it shall be done after the pieces forming one built member are assembled and so firmly bolted together that the surfaces shall be in close contact. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted.]

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*See Addendum, clause (d).

122. Reaming shall be done with twist drills and without using any lubricant.

123. The outside burrs on reamed holes shall be removed to the extent of making a $\frac{1}{16}$-in. fillet.

Assembling.

124. Riveted members shall have all parts well pinned up and firmly drawn together with bolts, before riveting is commenced. Contact surfaces to be painted. (See 152.)

Lattice Bars.

125. Lattice bars shall have neatly rounded ends, unless otherwise called for.

Web Stiffeners.

126. Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for, the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

Splice Plate and Fillers.

127. Web splice plates and fillers under stiffeners shall be cut to fit within ⅛-in. of flange angles.

Web Plates.

128. Web plates of girders, which have no cover plates, shall be flush with the backs of angles or project above the same not more than ⅛-in., unless otherwise called for. When web plates are spliced, not more than ¼-in. clearance between ends of plates will be allowed.

Floor Beams and Stringers.

129. The main sections of floor beams and stringers shall be milled to exact length after riveting and the connection angles accurately set flush and true to the milled ends *[or if required by the purchaser the milling shall be done after the connection angles are riveted in place, milling to extend over the entire face of the member]. The removal of more than 3/32-in. from the thickness of the connection agles will be cause for rejection.

Riveting.

130. Rivets shall be uniformly heated to a light cherry red heat in a gas or oil furnace so constructed that it can be adjusted to the proper temperature. They shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving.

131. Rivets shall look neat and finished, with heads of approved shape, full and of equal size. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced.

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*See Addendum, clause (f).

In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary, they shall be drilled out.

Turned Bolts. 132. Wherever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel and the bolts shall make a driving fit, with the threads entirely outside of the holes. A washer not less than ¼-in. thick shall be used under nut.

Members to be Straight. 133. The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends or open joints.

Finish of Joints. 134. Abutting joints shall be cut or dressed true and straight and fitted close together, especially where open to view. In compression joints, depending on contact bearing, the surfaces shall be truly faced, so as to have even bearings after they are riveted up complete and when perfectly aligned.

Field Connections. 135. Holes for floor beam and stringer connections shall be sub-punched and reamed according to paragraph 120, to a steel templet not less than one inch thick. *[If required, all other field connections, except those for laterals and sway bracing, shall be assembled in the shop and the unfair holes reamed; and when so reamed the pieces shall be match-marked before being taken apart.]

Eye-Bars. 136. Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than $\frac{1}{16}$-in. from that specified. (See 163.)

Boring Eye-Bars. 137. Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin-holes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins 1/32-in. smaller in diameter than the pin-holes can be passed through the holes at both ends of the bars at the same time without forcing.

Pin Holes. 138. Pin-holes shall be bored true to gages, smooth and straight; at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up.

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*See Addendum, clause (e).

139. The distance center to center of pin-holes shall be correct within $\frac{1}{32}$-in., and the diameter of the holes not more than $\frac{1}{50}$-in. larger than that of the pin, for pins up to 5-in. diameter, and $\frac{1}{32}$-in. for larger pins.

Pins and Rollers. 140. Pins and rollers shall be accurately turned to gages and shall be straight and smooth and entirely free from flaws.

Screw Threads. 141. Screw threads shall make tight fits in the nuts and shall be U. S. standard, except above the diameter of 1⅜ in., when they shall be made with six threads per inch.

Annealing. 142. Steel, except in minor details, which has been partially heated, shall be properly annealed.

Steel Castings. 143. Steel castings shall be free from large or injurious blowholes and shall be annealed.

Welds. 144. Welds in steel will not be allowed.

Bed Plates. 145. Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed top and bottom. The finishing cut of the planing tool shall be fine and correspond with the direction of expansion.

Pilot Nuts. 146. Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered.

Field Rivets. 147. Field rivets shall be furnished to the amount of 15 per cent. plus ten rivets in excess of the nominal number required for each size.

Shipping Details. 148. Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

Weight. 149. The scale weight of every piece and box shall be marked on it in plain figures.

Finished Weight. 150. Payment for pound price contracts shall be by scale weight. No allowance over 2 per cent. of the total weight of the structure as computed from the plans will be allowed for excess weight.

VIII. SHOP PAINTING.

Cleaning. *151. Steel work, before leaving the shop, shall be thoroughly cleaned and given one good coating of pure linseed oil, or such paint as may be called for, well worked into all joints and open spaces.

Contact Surfaces. 152. In riveted work, the surfaces coming in contact shall each be painted before being riveted together.

Inaccessible Surfaces. 153. Pieces and parts which are not accessible for painting after erection, including tops of stringers, eye-bar heads, ends of posts and chords, etc., shall have an additional coat of paint before leaving the shop.

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*See Addendum, clause (b).

Condition of Surfaces.

154. Painting shall be done only when the surface of the metal is perfectly dry. It shall not be done in wet or freezing weather, unless protected under cover.

Machine-Finished Surfaces.

155. Machine-finished surfaces shall be coated with white lead and tallow before shipment or before being put out into the open air.

IX. INSPECTION AND TESTING AT THE SHOPS.

Facilities for Inspection.

156. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of workmanship at the shop where material is manufactured. He shall furnish a suitable testing machine for testing full-sized members, if required.

Starting Work.

157. The purchaser shall be notified well in advance of the start of the work in the shop, in order that he may have an inspector on hand to inspect material and workmanship.

Access to Shop.

158. When an inspector is furnished by the purchaser, he shall have full access, at all times, to all parts of the shop where material under his inspection is being manufactured.

Accepting Material.

159. The inspector shall stamp each piece accepted with a private mark. Any piece not so marked may be rejected at any time and at any stage of the work. If the inspector, through an oversight or otherwise, has accepted material or work which is defective or contrary to the specifications, this material, no matter in what stage of completion, may be rejected by the purchaser.

Shop Plans.

160. The purchaser shall be furnished complete shop plans.

Shipping Invoices.

161. Complete copies of shipping invoices shall be furnished to the purchaser with each shipment. These shall show the scale weights of individual pieces.

X. FULL-SIZED TESTS.

Eye-Bar Tests.

162. Full-sized tests on eye-bars and similar members, to prove the workmanship, shall be made at the manufacturer's expense, and shall be paid for by the purchaser at contract price, if the tests are satisfactory. If the tests are not satisfactory, the members represented by them will be rejected.

163. In eye-bar tests, the minimum ultimate strength shall be 55,000 lbs. per sq. in. The elongation in 10 ft., including fracture, shall

be not less than 15 per cent. Bars shall generally break in the body and the fracture shall be silky or fine granular, and the elastic limit as indicated by the drop of the mercury shall be recorded. Should a bar break in the head and develop the specified elongation, ultimate strength and character of fracture, it shall not be cause for rejection, provided not more than one-third of the total number of bars break in the head (see 136).

ADDENDUM TO GENERAL SPECIFICATIONS FOR STEEL RAILWAY BRIDGES.

POINTS TO BE SPECIFICALLY DETERMINED BY BUYERS WHEN SOLICITING PROPOSALS FOR STEEL RAILWAY BRIDGES.

When general detail drawings are not furnished for the use of bidders specific answers should be given to questions a, b and c, below.

Specific answers should also be given to questions d, e and f if the class of work described in any of the paragraphs there referred to is desired. If these features are not specifically demanded, the unbracketed paragraphs will be construed to define the kind of work desired.

(a) What class of live load shall be used? (Pars. 7 and 8.)

(b) Shall linseed oil or paint be used? If paint, what kind? (Par. 151.)

(c) Shall contractor furnish floor bolts?

(d) Shall general reaming be done? (Par. 121.)

(e) Shall field connections be assembled at the shop? (Par. 135.)

(f) Shall floor connection angles be milled after riveting? (Par. 129.)

*CLASSIFICATION OF BRIDGES AS TO SAFE CARRYING CAPACITY.

CARRYING CAPACITY.

(1) The carrying capacity of a bridge is here understood to mean the heaviest moving loads which may be operated over it in regular service for a limited time without subjecting it to such severe strains, motion or wear of parts as to seriously impair its safety and serviceability.

(2) The carrying capacity of any bridge will depend upon a large number of controlling factors, all of which must be taken into consideration. Some of these factors are design, material, workmanship, speed, strains, behavior, physical condition and the possibility of maintaining falsework for a considerable time should the bridge show distress under the increased loading.

(3) A railway bridge which has been constructed in accordance with a specification which provides for strength, design, material and workmanship at least equal to the specifications for steel railway bridges of the American Railway Engineering Association, will, when in good condition, carry for a limited period a loading in excess of that for which it was originally designed. The bridge, however, will be subjected to a greater amount of motion and wear of parts, have a lower margin of safety, less efficiency and a shorter life.

(4) When the span is less than 200 ft., all controlling factors given in paragraph 2 good, the mathematical analysis made in accordance with the American Railway Engineering Association specifications of 1910, using full specification allowances for impacts for regular service fast speed and one-half of these impact allowances for speeds not exceeding 15 miles per hour, then, so long as the controlling factors remain good, unit strains in tension to the extent of 26,000 lbs. in structural open-hearth steel and 22,000 lbs. in wrought-iron, will not, in themselves, be sufficient justification for suspending traffic or condemning the structure.

(5) When the controlling factors as outlined in paragraph 2 are not good, the limiting strains or capacities cannot be determined by any general rule, as they are questions of actual conditions, judgment and experience, supplemented by a close watch on the structure in service.

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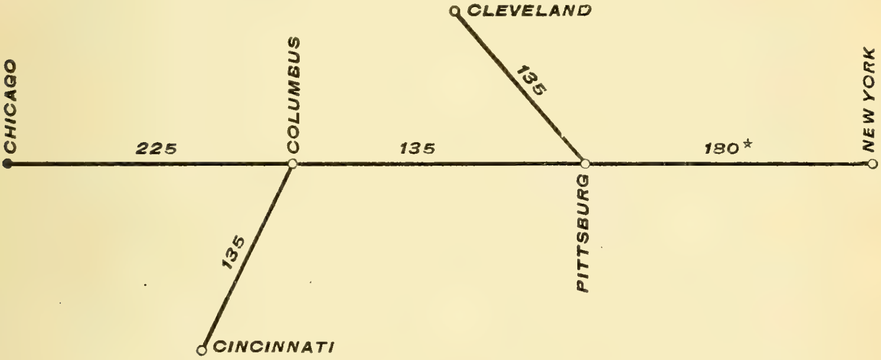
* Adopted, Vol. 9, 1908, pp. 218-221, 285-296.

CLASSIFICATION FOR OPERATING PURPOSES.

(1) Bridges should be classified for operating purposes according to their efficiencies under a loading of the type outlined in the American Railway Engineering Association specifications. The efficiencies should be indicated by figures representing either the total weight or driving axle weight of the heaviest permissible engine of the specification type, and these figures should be placed on the map of the railway in such a manner as to show at a glance the capacity of the weakest structure on the main line, branches and engine districts. A schedule on this map will give the service classes of engines and cars whose operation is permitted by the stated efficiencies. Notes on the map will indicate restrictions as to speed and double-headers, and in order that these notes may not be overlooked an asterisk may be placed after the number indicating the efficiency on that section of the road where there are restrictions as to double-headers and speed. The accompanying map illustrates briefly the above scheme.



Schedule showing heaviest equipment of each service class which may be operated when the bridge efficiency is stated:

Efficiency.	Service Class.			
225	A250	B240	C130	D220
180	A200	B190	C180	D170
135	A150	B140	C130	D120

The figures denote weight in 1,000 lbs. of engine, exclusive of tender.

Speed restriction: Ten miles on Bridge 23 at Pittsburg.

Double-headers: No restriction except ....

Note.—If preferred, the efficiency may be indicated by the driving axle-load in accordance with Cooper's series instead of by the weight as above shown.

[*]INSPECTION OF BRIDGES AND RECORDS OF INSPECTION.

(1) Inspection by the regular section forces, daily, or as often as they inspect the track under their supervision. The object of this inspection is to discover any damage to the structure from fire, flood, derailments or other accidents from traffic, or any displacement in the structure in whole or in part. This inspection, due to the lack of skill on the part of the section forces, must necessarily be superficial, and will rarely, if ever, do more than call attention to unsafe conditions arising from causes other than those of natural depreciation. No reports of such inspections need be made unless adverse conditions are discovered.

(2) At periodic intervals of from one to six months there should be inspections by bridge foremen and others experienced in bridge repairs. These inspections should be more thorough than those of the section forces, and are intended to discover all the defects, arising from traffic, to which the bridge is subjected, and those due to natural depreciation or other causes. Reports of such inspections should be made to the one next in authority; preferably to the one most directly or primarily responsible for the safety of the structures.

(3) Annual or semi-annual inspections are to be made by men experienced in the design and maintenance of bridges; preferably by those who are primarily responsible for their safe maintenance. The reports of these inspections should be filed, and in connection with an examination of office data will determine the safety of the structures, and be the basis for decisions as to repairs, reinforcements or renewals.

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[*] Adopted, Vol. 11, Part 1, 1910, pp. 126, 127, 166.

COMMITTEE XVI.

ECONOMICS OF RAILWAY LOCATION.

*POWER.

(1) Actual drawbar pull of the locomotive at various speeds should be used in making estimates with reference to economic value of various locations of line and grade, where such drawbar pull is known. Where not known, the drawbar pull should be calculated. In comparing a new line with an existing line the same percentage of efficiency of drawbar pull should be used in both cases.

(2) The tractive power of a locomotive depends upon its steam-producing capacity, the boiler pressure, the adhesion, and the size of the cylinders and drivers.

(3) The steam-producing capacity of a locomotive depends mainly upon the quantity and quality of the fuel burned, and the area of heating surface.

(4) Knowing the area of heating surface, the average steam production of locomotives burning bituminous and similar coals can be estimated by the use of Table 1, assuming 4,000 lbs. of coal as the maximum quantity that can be properly "fired" per hour.

(5) The maximum velocity at which full cut-off can be maintained can be found by dividing the pounds steam produced per minute by the quantity of steam used per revolution of the drivers, as shown in Table 2. Dividing this quotient by the coefficient given in Table 3 for the diameter of the drivers will give the speed in miles per hour at which full cut-off can be maintained. This velocity is referred to as "M" in the tables.

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* Adopted, Vol. 11, Part 1, 1911, pp. 631-664, 709-715.

TABLE 1

Average Evaporation in Locomotive Boilers

Burning bituminous and similar coals of various qualities and for various quantities consumed per square foot of heating surface per hour.

Based on Feed Water at 60° F.; Boiler Pressure, 200 lbs.

Lbs. Coal per Sq. Ft. H. Surface per Hour	Pounds Steam per Pound of Coal of Given Thermal Value					
	15,000 B. T. U.	14,000 B. T. U.	13,000 B. T. U.	12,000 B. T. U.	11,000 B. T. U.	10,000 B. T. U.
0.8	7.86	7.34	6.81	6.29	5.76	5.24
0.9	7.58	7.07	6.57	6.06	5.56	5.05
1.0	7.31	6.82	6.34	5.85	5.36	4.87
1.1	7.06	6.59	6.12	5.65	5.18	4.71
1.2	6.82	6.37	5.91	5.46	5.00	4.55
1.3	6.59	6.15	5.71	5.27	4.83	4.39
1.4	6.37	5.95	5.52	5.10	4.67	4.25
1.5	6.17	5.76	5.35	4.94	4.52	4.11
1.6	5.97	5.57	5.18	4.78	4.38	3.98
1.7	5.79	5.40	5.02	4.63	4.25	3.86
1.8	5.61	5.24	4.86	4.49	4.12	3.74
1.9	5.44	5.08	4.71	4.35	3.99	3.63
2.0	5.27	4.92	4.57	4.22	3.86	3.51
2.1	5.12	4.78	4.44	4.10	3.75	3.41
2.2	4.97	4.64	4.31	3.98	3.64	3.31
2.3	4.83	4.51	4.19	3.86	3.54	3.22
2.4	4.69	4.38	4.07	3.75	3.44	3.13
2.5	4.56	4.26	3.95	3.65	3.34	3.04
2.6	4.44	4.14	3.84	3.55	3.25	2.96
2.7	4.32	4.03	3.74	3.46	3.17	2.88
2.8	4.21	3.93	3.64	3.37	3.09	2.80
2.9	4.10	3.83	3.55	3.28	3.01	2.73
3.0	3.99	3.73	3.46	3.19	2.93	2.66

The quantity of steam evaporated for intermediate quantities or qualities of coal can be found by interpolation.

On bad water districts deduct the following from tabular quantities:

For each $\frac{1}{16}$-in. of accumulated scale ....10 per cent.

For each grain per U. S. gallon of foaming salts in the average feed water.............................. 1 per cent.

TABLE 2

WEIGHT OF STEAM USED IN ONE FOOT OF STROKE IN LOCOMOTIVE CYLINDERS.

Cylinder diameter is for high pressure cylinders in compound locomotives.

Diameter of Cylinder in Inches	WEIGHT OF STEAM PER FOOT STROKE FOR VARIOUS GAGE PRESSURES						
	220 lbs.	210 lbs.	200 lbs.	190 lbs.	180 lbs.	170 lbs.	160 lbs.
12	0.405 lbs.	0.389 lbs.	0.370 lbs.	0.354 lbs.	0.337 lbs.	0.321 lbs.	0.304 lbs.
13	0.475 “	0.456 “	0.435 “	0.415 “	0.396 “	0.376 “	0.357 “
14	0.551 “	0.529 “	0.504 “	0.482 “	0.459 “	0 436 “	0.414 “
15	0.633 “	0.607 “	0.579 “	0.553 “	0.527 “	0.501 “	0.476 “
15½	0.675 “	0.649 “	0.618 “	0.590 “	0.562 “	0.535 “	0.508 “
16	0.720 “	0.691 “	0.658 “	0.629 “	0.599 “	0.570 “	0.541 “
17	0.812 “	0.780 “	0.744 “	0.710 “	0.676 “	0.643 “	0.611 “
18	0.911 “	0.875 “	0.834 “	0.796 “	0.759 “	0.722 “	0.685 “
18½	0.962 “	0.924 “	0.881 “	0.841 “	0.801 “	0.762 “	0.724 “
19	1.015 “	0.975 “	0.928 “	0.887 “	0.845 “	0.804 “	0.763 “
19½	1.069 “	1.027 “	0.978 “	0.934 “	0.890 “	0.847 “	0.804 “
20	1.125 “	1.080 “	1.029 “	0.983 “	0.936 “	0.891 “	0.846 “
20½	1.181 “	1.134 “	1.081 “	1.032 “	0.984 “	0.936 “	0.888 “
21	1.240 “	1.191 “	1.134 “	1.083 “	1.032 “	0.982 “	0.932 “
22	1.361 “	1.307 “	1.245 “	1.189 “	1.133 “	1.078 “	1.023 “
23	1.487 “	1.428 “	1.361 “	1.300 “	1.238 “	1.178 “	1.118 “
28	2.204 “	2.117 “	2.017 “	1.926 “	1.835 “	1.745 “	1.657 “

For weight of steam used per revolution of drivers at full cut-off:—Multiply the tabular quantity by four times the length of stroke in feet for simple and four cylinder compounds. For two cylinder compounds multiply by two times the length of stroke.

TABLE 3

Values of Coefficient "C" for Changing Revolutions per Minute of Drivers Into Velocity in Miles per Hour.

$$\text{"C"} = \frac{336.13}{\text{Diameter of drivers in inches.}}$$

$$\text{Miles per hour} = \frac{\text{Revolutions per minute}}{\text{"C"}}$$

Diam.	"C"	Diam.	"C"	Diam.	"C"	Diam.	"C"
50 in.	6.72	58 in.	5.79	66 in.	5.09	74 in.	4.54
51 "	6.59	59 "	5.69	67 "	5.01	75 "	4.48
52 "	6.46	60 "	5.60	68 "	4.94	76 "	4.42
53 "	6.34	61 "	5.51	69 "	4.87	77 "	4.36
54 "	6.22	62 "	5.42	70 "	4.80	78 "	4.31
55 "	6.11	63 "	5.33	71 "	4.73	79 "	4.25
56 "	6.00	64 "	5.25	72 "	4.67	80 "	4.20
57 "	5.89	65 "	5.17	73 "	4.60	81 "	4.15

TABLE 4

MAXIMUM CUT-OFF AND POUNDS OF STEAM PER I. HP. HOUR FOR VARIOUS MULTIPLES OF "M."

"M"=Maximum velocity in miles per hour at full cut-off.
Boiler pressure, 200 lbs.

Velocity	Per Cent. Cut-Off	Pounds Steam per I. HP. Hour		Velocity	Per Cent. Cut-Off	Pounds Steam per I. HP. Hour	
		Simple Locomotive	Compound Locomotive			Simple Locomotive	Compound Locomotive
1.0 M.	Full	38.30	25.80	2.9 M.	38.5	24.37	21.04
1.1 "	94.4	36.46	24.36	3.0 "	37.0	24.22	21.21
1.2 "	89.1	34.89	23.24	3.2 "	34.2	24.00	21.57
1.3 "	84.3	33.56	22.35	3.4 "	31.8	23.85	21.93
1.4 "	79.7	32.41	21.65	3.6 "	29.8	23.8	22.27
1.5 "	75.4	31.40	21.14	3.8 "	28.0	23.8	22.57
1.6 "	71.4	30.49	20.77	4.0 "	26.4	23.87	22.85
1.7 "	67.7	29.67	20.52	4.25 "	24.7	24.05	23.22
1.8 "	64.3	28.93	20.40	4.50 "	23.3	24.24	23.56
1.9 "	61.0	28.25	20.40	4.75 "	22.1	24.44	23.85
2.0 "	58.0	27.62	20.40	5.00 "	21.1	24.64	24.15
2.1 "	55.2	27.05	20.40	5.5 "	19.5	24.98	24.70
2.2 "	52.6	26.52	20.40	6.0 "	18.4	25.20	
2.3 "	50.1	26.06	20.40	6.5 "	17.6	25.45	
2.4 "	47.8	25.67	20.40	7.0 "	17.1	25.60	
2.5 "	45.7	25.32	20.47	7.5 "	16.7	25.70	
2.6 "	43.7	25.02	20.60	8.0 "	16.4	25.80	
2.7 "	41.8	24.76	20.73	9.0 "	16.1	25.90	
2.8 "	40.1	24.54	20.88				

For steam per I. HP. hour for other boiler pressures take the following percentages of values given in table:

160 lbs., 103 per cent.	190 lbs., 100.6 per cent.
170 lbs., 102.1 per cent.	210 lbs., 99.5 per cent.
180 lbs., 101.3 per cent.	220 lbs., 99.2 per cent.

TABLE 5

PER CENT. CYLINDER TRACTIVE POWER
FOR
VARIOUS MULTIPLES OF "M."

"M"=Maximum Velocity in Miles per hour at which Boiler Pressure can be maintained with full cut-off.

Velocity	Compound per cent.	Simple per cent.	Velocity	Compound per cent.	Simple per cent.	Velocity	Compound per cent.	Simple per cent.
Start	(Simple) 135.00	106.00	3.6 M.	32.40	44.75	6.4 M.		23.59
0.5 M.	103.00	103.00	3.7 "	31.25	43.56	6.5 "		23.18
1.0 "	100.00	100.00	3.8 "	30.10	42.39	6.6 "		22.79
1.1 "	96.28	95.57	3.9 "	29.14	41.24	6.7 "		22.42
1.2 "	92.55	91.53	4.0 "	28.24	40.10	6.8 "		22.06
1.3 "	88.83	87.83	4.1 "	27.38	39.00	6.9 "		21.71
1.4 "	85.12	84.46	4.2 "	26.56	37.96	7.0 "		21.38
1.5 "	81.40	81.37	4.3 "	25.77	36.97	7.1 "		21.06
1.6 "	77.68	78.55	4.4 "	25.03	36.03	7.2 "		20.75
1.7 "	73.96	75.97	4.5 "	24.34	35.13	7.3 "		20.45
1.8 "	70.25	73.60	4.6 "	23.69	34.26	7.4 "		20.16
1.9 "	66.54	71.41	4.7 "	23.07	33.41	7.5 "		19.88
2.0 "	63.21	69.37	4.8 "	22.48	32.59	7.6 "		19.61
2.1 "	60.20	67.47	4.9 "	21.92	31.82	7.7 "		19.34
2.2 "	57.48	65.67	5.0 "	21.38	31.11	7.8 "		19.08
2.3 "	54.97	63.94	5.1 "	20.87	30.42	7.9 "		18.82
2.4 "	52.68	62.22	5.2 "	20.37	29.75	8.0 "		18.57
2.5 "	50.42	60.55	5.3 "	19.89	29.10	8.1 "		18.33
2.6 "	48.16	58.92	5.4 "	19.43	28.48	8.2 "		18.09
2.7 "	46.08	57.33	5.5 "	18.99	27.87	8.3 "		17.86
2.8 "	44.10	55.78	5.6 "		27.33	8.4 "		17.64
2.9 "	42.29	54.26	5.7 "		26.81	8.5 "		17.43
3.0 "	40.57	52.78	5.8 "		26.30	8.6 "		17.22
3.1 "	38.95	51.33	5.9 "		25.81	8.7 "		17.01
3.2 "	37.42	49.91	6.0 "		25.34	8.8 "		16.82
3.3 "	35.98	48.55	6.1 "		24.88	8.9 "		16.63
3.4 "	34.66	47.24	6.2 "		24.44	9.0 "		16.45
3.5 "	33.53	45.97	6.3 "		24.01			

TABLE 6

POUNDS TRACTIVE POWER FOR ONE HORSEPOWER AT VARIOUS SPEEDS.

Formula: $\text{One HP.} = \dfrac{375}{\text{Velocity in miles per hour}}$

Velocity	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3	125.0	120.97	117.19	113.64	110.29	107.14	104.17	101.35	98.68	96.15
4	93.75	91.46	89.29	87.21	85.23	83.33	81.52	79.79	78.13	76.53
5	75.00	73.53	72.12	70.75	69.44	68.18	66.96	65.79	64.66	63.56
6	62.50	61.48	60.48	59.52	58.59	57.69	56.82	55.97	55.15	54.35
7	53.57	52.82	52.08	51.37	50.68	50.00	49.34	48.70	48.08	47.47
8	46.88	46.30	45.74	45.18	44.64	44.12	43.60	43.10	42.61	42.13
9	41.67	41.21	40.76	40.32	39.89	39.47	39.06	38.66	38.27	37.88
10	37.50	37.13	36.77	36.41	36.06	35.71	35.38	35.05	34.72	34.40
11	34.09	33.78	33.48	33.19	32.89	32.61	32.33	32.05	31.78	31.51
12	31.25	30.99	30.74	30.49	30.24	30.00	29.76	29.53	29.30	29.07
13	28.85	28.63	28.41	28.20	27.99	27.78	27.57	27.37	27.17	26.98
14	26.79	26.60	26.41	26.22	26.04	25.86	25.68	25.51	25.34	25.17
15	25.00	24.83	24.67	24.51	24.35	24.19	24.04	23.88	23.73	23.58
16	23.44	23.29	23.15	23.01	22.87	22.73	22.59	22.46	22.32	22.19
17	22.06	21.93	21.80	21.68	21.55	21.43	21.31	21.19	21.07	20.95
18	20.83	20.72	20.60	20.49	20.38	20.27	20.16	20.05	19.95	19.84
19	19.74	19.63	19.53	19.43	19.33	19.23	19.13	19.03	18.94	18.84
20	18.75	18.66	18.56	18.47	18.38	18.29	18.20	18.12	18.03	17.94
21	17.86	17.77	17.69	17.61	17.52	17.44	17.36	17.28	17.20	17.12
22	17.05	16.97	16.89	16.82	16.74	16.67	16.59	16.52	16.45	16.37
23	16.30	16.23	16.16	16.09	16.03	15.96	15.89	15.82	15.76	15.69
24	15.63	15.56	15.50	15.43	15.37	15.31	15.24	15.18	15.12	15.06
25	15.00	14.94	14.88	14.82	14.76	14.71	14.65	14.59	14.53	14.48
26	14.42	14.37	14.31	14.26	14.20	14.15	14.10	14.04	13.99	13.94
27	13.89	13.84	13.79	13.74	13.68	13.63	13.59	13.54	13.49	13.44
28	13.39	13.35	13.30	13.25	13.20	13.16	13.11	13.07	13.02	12.98
29	12.93	12.89	12.84	12.80	12.76	12.71	12.67	12.63	12.58	12.54
30	12.50	12.46	12.42	12.38	12.34	12.30	12.26	12.22	12.18	12.14
31	12.10	12.06	12.02	11.98	11.94	11.90	11.87	11.83	11.79	11.76
32	11.72	11.68	11.65	11.61	11.57	11.54	11.50	11.47	11.43	11.40
33	11.36	11.33	11.30	11.26	11.23	11.19	11.16	11.13	11.09	11.06
34	11.03	11.00	10.96	10.93	10.90	10.87	10.84	10.81	10.78	10.74
35	10.71	10.68	10.65	10.62	10.59	10.56	10.53	10.50	10.47	10.44
36	10.42	10.39	10.36	10.33	10.30	10.27	10.24	10.21	10.18	10.16

For intermediate velocities, values per horse-power can be found by interpolation.

TABLE 7

Locomotive Resistances.

Ⓐ Cylinder to Rim of Drivers:
Total Pounds $R=18.7T+80N$.
T=Tons Weight on Drivers.
N=Number Driving Axles.

Ⓑ Engine and Tender Trucks:
Total Pounds $R=2.6T+20N$.
T=Tons Weight on Engine and Tender Trucks.
N=Number of Truck Axles.

Ⓒ Head End or "Air" Resistance.
$R=.002V^2A$;......
V=Velocity in Miles per Hour.
A=Area (Average for Locomotives, 125 sq. ft.).

Total $R=0.25V^2$.

Air Resistance (C) for Various Velocities.

Velocity	R	Velocity	R	Velocity	R	Velocity	R
1	0.25	11	30	21	110	31	240
2	1.00	12	36	22	121	32	256
3	2.25	13	42	23	132	33	272
4	4.00	14	49	24	144	34	289
5	6.25	15	56	25	156	35	306
6	9.00	16	64	26	169	36	324
7	12.25	17	72	27	182	37	342
8	16.00	18	81	28	196	38	361
9	20.25	19	90	29	210	39	380
10	25.00	20	100	30	225	40	400

Drawbar pull on level tangent equals the cylinder Tractive Power less the sum of Engine Resistances.

At Low Speeds the adhesion of drivers should be considered and available drawbar pull should never be estimated greater than 30 per cent. of Weight on Drivers at starting with use of sand, 25 per cent. of Weight on Drivers at running speeds.

(6) Tractive power of a locomotive is greatest at starting, gradually reducing to the maximum velocity ("M") at which full cut-off can be maintained. At speeds above this velocity the tractive power decreases more rapidly. The tractive power at any multiple of "M" is practically a fixed percentage of the tractive power at "M". The fixed percentages are different for compound types than for simple locomotives.

(7) Knowing the steam production of a locomotive and the maximum velocity at which full cut-off can be maintained ("M"), the indicated horse-power of the locomotive can be obtained for velocity "M" or higher velocities by dividing the total steam produced per hour by the quantity of steam used per I. HP. hour, as given in Table 4, after applying the corrections for proper boiler pressure.

(8) Horse-power can be converted into tractive power by the formula, tractive power equals 375 times the HP., divided by the velocity in miles per hour. To simplify the operation, the tractive power can be obtained by multiplying the HP. by the figures shown in Table 6.

(9) Where I. HP. at "M" velocity has been converted into cylinder tractive power, the cylinder tractive power at other multiples of "M" can be determined by using the percentages given in Table 5 without first calculating the I. HP. for the respective multiples of "M."

(10) Available drawbar pull on level tangent is the cylinder tractive power less the sum of the resistances from the cylinder to the rim of drivers, the resistance through the trucks of engine and tender, and the "head end" or velocity resistance. The formulas and data given in Table No. 7 are recommended for use in determining these resistances. Available drawbar pull at starting, with use of sand, should not be considered as greater than 30 per cent. of the weight on locomotive drivers and at running speeds not greater than 25 per cent.

*TRAIN RESISTANCE.

(1) Dynamometer tests to be of the greatest value should show the following:

(a) Dynamometer record (graphical) showing drawbar pull to nearest ten pounds, with horizontal scale not less than 400 ft. to one inch and in special cases a larger scale.

(b) Speed record to nearest tenth of mile per hour (graphical).

(c) Key to record mile posts.

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* Adopted, Vol. 11, Part 2, 1911, pp. 647-666, 715-731.

(d) Condition of track surface and gage (graphical).

(e) Steam pressure of boiler (graphical).

(f) Train line air pressure (graphical).

(g) Time record (graphical).

(Speed record may be independent record, and in this case time record is desirable.)

(h) Coal consumption (record of shovels of coal as used) (worked by hand in engine).

Requisite data to be taken:

TRACK.

(i) Office profile and alinement connecting with mile posts (so as to connect with 3).

(j) Section of rail.

(k) Condition of rail.

(l) Number of ties to rail (and rail length).

(m) Kind and quantity of ballast.

LOCOMOTIVE.

(n) Type (wheel arrangement, whether simple or compound and dimensions of locomotive).

(o) Total weight and weight on drivers.

CARS.

(p) Record of length, initial, number, class of each car of train; also weight empty and weight loaded.

(q) Kind of truck.

(r) Condition of car.

WEATHER.

(s) Temperature.

(t) Direction of force of wind and direction of train.

(u) State of weather (rain or clear).

(2) Resistance of freight trains shows practically no change of resistance between seven and thirty-five miles per hour.

(3) It is recommended that for freight train resistances between seven and thirty-five miles per hour the formula,

$$R = 2.2\,T + 121.6\,C,$$

be used for comparing freight train ratings on different lines and grades.

R = total resistance on level tangent.

T = total weight cars and contents in tons.

C = total number of cars.

(4) In order to equalize resistance on curves and tangent, curves should be ordinarily compensated .035 per cent. per degree of curvature. Effect of curve resistance is dispelled more slowly at slow speed than at high speed.

(5) Condition of roadway maintenance has a great effect on train resistance.

(6) Condition and design of equipment has a great effect on train resistance.

(7) Train resistance is greater in cold weather than in warm. Per cent. of rating on account of variation in temperature, as shown in following table, is recommended for use in comparing new lines, and not for tonnage rating:

PER CENT. OF RATING TO BE USED FOR VARIOUS TEMPERATURES BASED ON TESTS ON .3 PER CENT., 1 PER CENT. AND 2.6 PER CENT. GRADES.

Per Cent. of Grade	A Above 45°	B 45° to 35°	C 35° to 20°	D Below 20°
.3	100	88	76	65
.35	100	90	80	69
.4	100	91	82	72
.45	100	91	83	74
.5	100	92	84	76
.55	100	93	86	78
.6	100	93	87	80
.65	100	94	88	82
.7	100	94	88	83
.75	100	95	89	84
.8	100	95	90	85
.85	100	95	90	85
.9	100	95	90	86
.95	100	96	92	87
1.0	100	96	92	88
1.1	100	96	92	89
1.2	100	97	93	90
1.3	100	97	94	91
1.4	100	97	94	91
1.5	100	97	94	92
1.6	100	97	94	92
1.7	100	98	95	93
1.8	100	98	95	93
1.9	100	98	96	94
2.0	100	98	96	94
2.2	100	98	96	95
2.4	100	99	97	96
2.6	100	99	97	96

(8) Resistance of individual cars of same weight but of different type shows considerable variation. Sufficient data are not yet available to determine just how much the difference is.

(9) Starting resistance varies from 10 to 40 lbs. per ton, depending on loading, temperature and character of maintenance of roadway and equipment.

* CURVATURE.

(1) A straight line is the ideal alinement.

(2) The justifiable expenditure to eliminate one degree of central angle in the alinement of roadway depends largely on the number of daily trains and the cost per train per mile.

(3) As a general rule it is good practice to spend more money to take out one degree of central angle where the radius is small, requiring the maximum elevation of the outer rail, than where the radius is large, requiring less elevation.

(4) As a general rule, it is justifiable to spend more money to take out one degree of central angle where trains run at a high rate of speed than where the speed is low.

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* Adopted, Vol. 11, Part 1, 1911, pp. 666-669, 732, 733.

COMMITTEE XVII.

WOOD PRESERVATION.

*GENERAL REQUIREMENTS.

(1) Creosote oil and zinc-chloride are effective wood preservatives when properly applied and when used under proper conditions.

(2) Accurate records should be kept in order to form proper conclusions as to the merit of different methods and processes.

(3) Preserved wood may be destroyed by mechanical action long before it is decayed, and therefore should be protected by economical devices when the mechanical life limits the life of the tie.

(4) There should be a standard temperature at which creosote oil is measured. The temperature of 100 degrees Fahrenheit is recommended.

(5) It is essential that timber should be properly grouped in order that a successful treatment may be obtained. The species, proportion of heartwood and sapwood, condition of the timber with respect to its moisture content and the wood structure, will in general determine this grouping.

(6) It is desirable to air-season timber in order to prepare it for treatment. Most woods can be best treated after being air-seasoned.

(7) All chemicals used should be tested for purity from time to time. Either the chemists for the company will do this themselves or indicate some simple tests which may be applied by operatives at the works.

(8) In operating with zinc-chloride, the strength of the solution should be varied from time to time to conform to the kind and condition of the ties, so as to inject the required quantities. But in no case should the strength of the solution exceed 5 per cent.

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* Adopted, Vol. 10, 1909, pp. 629-631, 669-676; Vol. 11, Part 2, 1910, pp. 737, 761, 859; Vol. 12, 1911.

(9) It is better to inject quantities of the chemicals in excess of the requirements than to skimp the treatment in any way.

(10) Daily reports should be kept at the works, and duplicates sent to the general office, if desired, in order to check the operation.

(11) Ties treated with zinc-chloride should dry for some little time (to harden the outer surface) before they are put in the tracks. This is preferably done in piles, arranged to induce drying without checking as evaporation takes place.

(12) For best results it is recommended that certain sections of track be selected on each railroad for the purpose of making accurate tests covering the life of treated and untreated ties of various kinds of timber and under various treatments, and that an accurate record be kept of the life of all ties in these test sections of track in order to be able hereafter to improve on the treatment. All ties inserted in such test sections shall be marked with dating nails, and, if necessary, with other identification marks.

(13) In order to judge of the penetration of the oil, borings should be made with an auger, ¾ to 1 in. in diameter, in not less than six ties in each cylinder load. The holes should be plugged with creosoted turned plugs of diameter $\frac{1}{16}$-in. larger than the holes.

(14) All bridge material intended for treatment should be framed, as far as possible, before timbers are placed in the treating cylinder. This includes the boring of the necessary holes.

*STANDARD SPECIFICATIONS FOR CREOSOTE OIL.

(1) The oil used shall be the best obtainable grade of coal-tar creosote; that is, it shall be a pure product of coal-tar distillation and shall be free from admixture of oils, other tars or substances foreign to pure coal-tar; it shall be completely liquid at thirty-eight (38) degrees Centigrade, and shall be free from suspended matter; the specific gravity of the oil at thirty-eight (38) degrees Centigrade shall be at least 1.03. When distilled according to the common method, that is, using an eight (8) ounce retort, asbestos covered, with standard thermometer, bulb one-half (½) in. above the surface of the oil, the creosote, calculated on the basis of the dry oil, shall give no distillate below two hundred (200) degrees Centigrade, not more than five (5) per cent. below two hundred and ten (210) degrees Centigrade, not more than twenty-five (25)

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* Adopted, Vol. 10, 1909, pp. 621, 629-631, 669-676.

per cent. below two hundred and thirty-five (235) degrees Centigrade, and the residue above three hundred and fifty-five (355) degrees Centigrade, if it exceeds five (5) per cent. in quantity, shall be soft. The oil shall not contain more than three (3) per cent. water.

*SPECIFICATIONS FOR ANALYSIS OF CREOSOTE OIL.

1. The sample taken for analysis shall be strictly average of the whole bulk of oil to be tested. The oil shall be completely liquefied and well mixed before samples are taken. Whenever possible a drip sample of not less than two gallons shall be taken commencing after the oil has started to run freely. When this cannot be done, as for instance, in large storage tanks, samples shall be taken from various depths in the tank by means of a tube or bottle, the number of samples depending on local conditions.

For taking samples during the process of treatment a sample of the oil shall be taken from the storage tank about one foot from the bottom of the tank before the cylinder is filled, and, where possible, a sample directly from the cylinder during the process of treatment. For this purpose a thermometer well, as shown in diagram, may be used.

The sample to be analyzed shall be thoroughly liquefied by heating until no crystals adhere to a glass stirring rod, and also well shaken, after which one-half shall be taken for analysis and the balance reserved as a check test.

2. The apparatus for distilling the creosote shall consist of a stoppered glass retort similar to that shown in diagram having a capacity as nearly as can be obtained of eight ounces up to the bend of the neck when the bottom of the retort and the mouth of the off-take are in the same plane. A nitrogen filled mercury thermometer of good standard make, divided into full degrees Centigrade, shall be used in connection therewith. In order to insure uniform results for comparative purposes, the length of the thermometer bulb shall be one-half (½) inch; but in no case shall a thermometer with a long bulb be used. The bulb of the retort and at least two (2) in. of the neck shall be and remain covered with a shield of heavy asbestos paper, shaped as shown in diagram, during the entire process of distillation, so as to prevent heat radiation, and between the bottom of the retort and the flame of

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*Adopted, Vol. 9, 1908, pp. 708-711, 768; Vol. 11, Part 2, 1911, pp. 743-746, 860.

the lamp or burner two sheets of wire gauze, each 20-mesh fine, and at least 6 in. square, shall be placed.

The flame shall be protected against air currents. An ordinary tin can, from which a portion of the bottom and all of the top have been removed, placed on a support attached to the burner, as shown in diagram, will answer the purpose.

3. Before beginning the distillation the retort shall be carefully weighed and exactly one hundred grammes of oil placed therein, the same being weighed in the retort. The thermometer shall be inserted in the retort with the lower end of the bulb one-half inch from the surface of the oil and the condensing tube attached to the retort by a tight cork joint. The distance between the bulb of the thermometer and the end of the condensing tube shall not be less than 20 nor more than 24 in., and during the progress of the distillation the thermometer shall remain in the position originally placed.

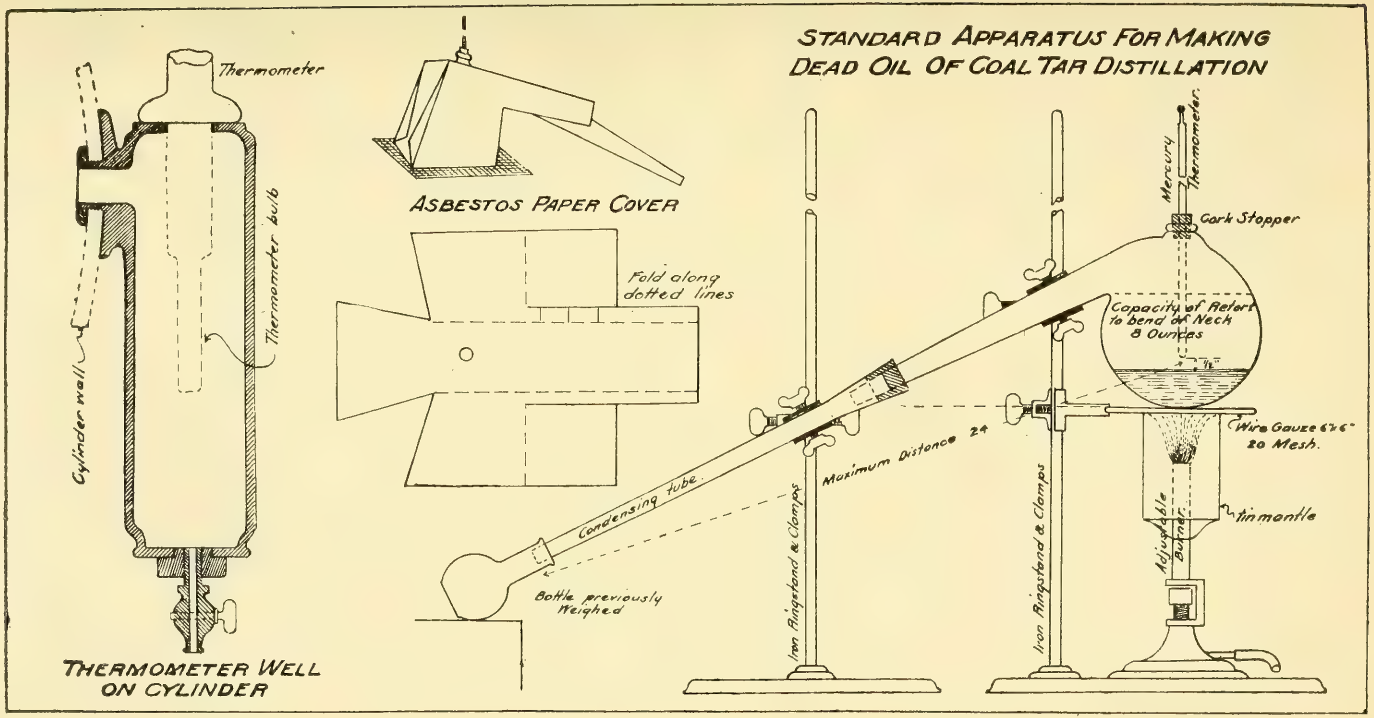
The distillate shall be collected in weighed bottles and all fractions determined by weight. Reports shall be made on the following fractions:

0 to 170 degrees Centigrade.
170 to 200 degrees Centigrade.
200 to 210 degrees Centigrade.
210 to 235 degrees Centigrade.
235 to 270 degrees Centigrade.
270 to 315 degrees Centigrade.
315 to 355 degrees Centigrade.
Residue above 355 degrees Centigrade.

Reports shall be made on individual fractions. In making such reports it is to be distinctly understood that these fractions do not necessarily refer to individual compounds. In other words, the fraction between 210 and 235 degrees will not necessarily be all naphthalene, but will probably contain a number of other compounds.

The distillation shall be a continuous one, and should require about forty-five minutes.

When any measurable quantity of water is present in the oil the distillation shall be stopped, the oil separated from the water and returned to the retort, when the distillation shall be recommenced and the previous readings discarded. In obtaining water-free oil, it is desirable to free about 300 to 600 cc. of the oil by using a large retort and using 100 grammes of the water-free oil for the final distillation. In the final report as to fractions, a correction shall be made of the amount of


STANDARD APPARATUS FOR MAKING DEAD OIL OF COAL TAR DISTILLATION

ASBESTOS PAPER COVER

THERMOMETER WELL ON CYLINDER

Thermometer
Thermometer bulb
Cylinder wall
Fold along dotted lines
Mercury
Thermometer.
Cork Stopper
Capacity of Retort to bend of Neck 8 Ounces
½"
Wire Gauze 6"x6" 20 Mesh.
tin mantle
Adjustable Burner.
Iron Ringstand & Clamps
Iron Ringstand & Clamps
Maximum Distance 24
Condensing tube
Bottle previously Weighed

water remaining, so that the report may be made on the basis of a dry oil.

4. In order to determine the specific gravity of any oil, simply heat the oil in a water bath until it is completely liquid. A glass stirring rod dipped into the liquid should show no solid particle on the rod when the same is withdrawn from the oil. When completely liquid, it should be stirred thoroughly and the hydrometer cylinder filled, which has previously been warmed. Insert a specific gravity hydrometer of good make, taking care that the hydrometer does not touch the sides or bottom of the cylinder when the reading is taken. This reading should preferably be taken when the oil is at 38 degrees Centigrade (100 degrees Fahrenheit), because at this temperature almost all oils are completely fluid. Where contract requirements specify a specific gravity at a different temperature, such gravity is obtained by multiplying .0008 by the number of degrees Centigrade, or .00044 by the number of degrees Fahrenheit, the oil is found to be above the temperature required by the contract, and adding the product to the observed gravity.

If it is desired to make further chemical analysis for the determination of the low-boiling tar acids and the naphthalene, the following method is recommended, tentatively:

For the determination of low-boiling tar acids, the fractions should be placed in a separating funnel, to which should be added about 30 cc. of the 15 per cent. hot sodium hydroxide solution, vigorously shaken, and allowed to stand until the dissolved phenols separate out and may be drawn off, after which repeat with successive sodium hydroxide solutions 20 cc. each time until no phenols are left (the sodium solution comes off clear). The phenols so obtained should be separated by the addition of a 25 per cent. sulphuric acid, slowly stirred in. When this reaction is complete, the phenols so obtained should be decanted and weighed.

*SPECIFICATIONS FOR TIE TREATMENT.

GENERAL REQUIREMENTS.

The General Requirements apply to each of the following treatments. If used in specifications for the purchase of ties or for treatment, then these General Requirements should be followed only by the particular treatment desired.

1. Ties shall not be treated until air-seasoned. If they arrive at the treating plant in a seasoned condition ready to treat, they may be loaded

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*Adopted, Vol 8, 1907, pp. 476-480, 520; Vol. 11, Part 2, 1910, pp. 737-743, 761, 858-860.

direct from the cars to the tram buggies; otherwise they shall be piled on the ground in their respective groups or classes, green ties separate from partially seasoned or from seasoned ties, and all resting on treated stringers, with not less than six (6) in. air space between bottom of lowest tier and ground; the spaces under, between and around the piles shall be thoroughly drained, and at all times kept clear of weeds, high grass and decaying matter. The top tier shall be laid sloping to form a water shed. Especial attention should be given to keeping all rotten wood off of the yard and away from the ties. Ties shall be piled either 8x1 or 8x2 or any other manner adapted to secure rapid and uniform seasoning with minimum checking. Alleys must be left between piles with four (4) ft. clear space in one direction and one foot in the other direction. These alleys will, in general, provide for uniform and fairly rapid seasoning.

Since the seasoning varies with the latitude, time of year, the exposure, and peculiarities of the season, it is best to establish by experiment the weight per cubic foot at which each class of timber will best receive the treatment, and then to weigh from time to time to determine when the timber is ready for treatment. Ties piled for seasoning shall be closely watched, and not allowed to over-season or to deteriorate.

Ties treated in the same run shall be as nearly as possible uniform in character of timber and degrees of seasoning. They shall, so far as practicable, be treated in order of their cutting, and shall be separated into groups according to their permeability, as ascertained by experiment. No ties shall be put into the cylinder which do not conform to the requirements of the tie specifications as to shakes, checks, etc. Ties which show signs of checking should be provided with "S" irons, bolts or other devices, in order to prevent, during or after treatment, further checking that would be liable to render the tie worthless. Where ties are to be adzed or bored for subsequent insertion of tie-plates or screw-spikes, such adzing and boring shall in all cases be done before treatment.

Thoroughly air-seasoned ties shall be placed in the cylinder and a preliminary vacuum of not less than 24 in. of mercury produced and maintained for a period of time not less than ten minutes, at the expiration of which the preservative shall be admitted without breaking the vacuum.

2. When ties that are not thoroughly air-seasoned must be treated, and are to be treated with metallic salts, the ties shall be placed in cylinders, the door closed and live steam admitted at such rate as to

secure 20 lbs. of steam pressure within 30 to 50 minutes, as shown by gage connected to the cylinder. This pressure shall be maintained for periods varying from one to five hours, depending upon the character of the timber and its condition; but the pressure as indicated on the gage shall at no time be allowed to exceed 20 lbs. During the process of steaming a vent shall be kept open in the bottom of the cylinder or in the drain therefrom to permit the escape of air and the condensed water in the cylinder.

When ties that are not seasoned must be treated, and are to be treated with creosote, either long steaming or seasoning in hot creosote oil within safe limits of heat, as determined by experience, may be resorted to.

When the steaming is completed the steam shall be blown off, and a vacuum of not less than 24 in. of mercury produced, if the works are located at sea level, or a corresponding degree of vacuum produced at higher altitude. This vacuum shall be maintained for at least one-half hour, at the expiration of which time the preservative shall be admitted without otherwise breaking the vacuum.

ZINC-CHLORIDE TREATMENT.

The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than five (5) per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils, steam pressure shall be maintained in these coils during treatment.

The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

The zinc-chloride used shall be as free from impurities of any kind as is practicable, being slightly basic, free from free acid, containing not more than 0.25 per cent. iron. The amount of chloride specified to be injected shall be of soluble zinc-chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tank holding the supply of solution. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in the tracks. The strength of the zinc-chloride solution shall be carefully controlled from time to time by hydrometer readings. Borings shall be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc-chloride according to the standard method made; the holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

ZINC-TANNIN TREATMENT.

The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than five (5) per cent.

The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. If the cylinders are provided with steam coils, steam shall be maintained in these coils during the entire treatment.

The cylinder shall be entirely filled with preservative so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

After the required amount of zinc-chloride has been injected, this solution shall be run off and the ties allowed to drain for 15 minutes. The chloride draining off shall be blown or run off, and a 2 per cent. solution of tannic acid, made by mixing 6⅔ lbs. of 30 per cent. extract of tannin with 100 lbs. of water, run in, and a pressure of 100 lbs. produced and maintained one-half hour. This shall then be run off, a 1 per cent. solution of glue (made by dissolving 2 1/10 lbs. of glue containing 50 per cent. gelatine in 100 lbs. water) shall be admitted to the cylinder, and a pressure of 100 lbs. produced and maintained for one-half hour. Care shall be taken to maintain the solution containing the glue and tannic acid up to their original strength in these elements.

The zinc-chloride used shall be as free from all impurities of any kind as is practicable, being slightly basic, free from free acid, containing not more than 0.25 per cent. iron. The amount of chloride specified to be injected shall be of soluble zinc-chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tanks holding the supply of solution. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in the tram tracks. The strength of the zinc-chloride solution shall be carefully controlled from time to time by hydrometer readings. Borings shall be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc-chloride according to the standard method made; the holes made in taking these borings to be plugged tightly and completely with creosoted plugs.

PLAIN CREOSOTING.

The creosote oil shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of oil to be injected shall be that provided for in the contract. Creosote oil shall be heated to a temperature of not less than 160 degrees before admission to the cylinder. Cylinders shall be provided with sufficient steam coils to fully maintain this temperature during injection.

The cylinder shall be entirely filled with preservative, so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

The creosote oil shall comply with the standard specifications therefor, as determined by standard method of analysis. The amount of oil absorbed shall be determined by calculation based upon gage readings taken on the same tank before the introduction of the oil into the cylinder and after forcing back the oil after treatment. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars before and after treatment, a scale being inserted in the tram tracks.

Daily reports of the injections shall be made. At least once a week an account of stock shall be taken and balance established to check the reported amounts used.

In making all measurements the oil should be at a constant temperature, or they should be reduced to a constant temperature by a proper reduction factor.

The oil shall be analyzed when received at the works; the samples being taken in the manner prescribed by the specifications for analysis of the oil. At least once during each week samples of oil shall be taken from the cylinders during the treatment and analyzed to determine if the water in the oil exceeds the limit in the specifications. If so, a correspondingly greater amount shall be injected. If this amount of water exceeds six (6) per cent. steps shall be taken before it is used to remove the water, so as to bring the oil within the limits of the specifications.

ZINC-CREOSOTE EMULSION TREATMENT.

An emulsion of zinc-chloride and suitable creosote oil, the latter being at least ten (10) per cent. of the whole, shall be admitted. Adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be such as to leave in the wood an equivalent of 4/10-lb. of dry soluble zinc-chloride and from 1¼ to 1½ lbs. of creosote per cubic foot on the average.

The zinc-chloride used shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than three and one-half (3½) per cent. It shall be as free from impurities as is practicable, free from free acid and containing not more than 0.25 per cent. of iron. The creosote oil used shall be as nearly as possible of the same specific gravity as the zinc-chloride solution. It should generally conform to the standard specifications for creosote of this Association, except that it should preferably contain a large percentage of tar acids and a small percentage of naphthalene. To insure as perfect a mixture of the emulsion of the zinc-chloride solution with the creosote oil as possible, an effective stirring apparatus must be used in the storage tank, and preferably also in the cylinder. The emulsion shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder, and if the latter is provided with steam coils pressure shall be maintained in these coils during treatments.

The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

Hydraulic pressure of 100 lbs. per sq. in. shall be applied upon the emulsion in the cylinder and shall be maintained until the required amounts are injected as above specified. The amount absorbed shall be determined by calculations based upon gage readings, both before the introduction of the emulsion into the cylinder and after forcing it back after treatment. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in tram tracks. Daily reports of the injections shall be made, and at least once a week an account of stock shall be taken and balance established to check the reported amounts used. In making all measurements the oil should be at a constant temperature, or the measurements should be reduced to a constant temperature by a proper reduction factor.

TWO-INJECTION ZINC CREOSOTE.

The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to 3/10-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than five (5) per cent. The solution shall be heated to a temperature of not less than 140 degrees before admission to the cylinder.

The cylinder shall be entirely filled with preservative, so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

The zinc-chloride used shall be free from all impurities of any kind as is practicable, being slightly basic, free from free acid, and containing not more than 0.25 per cent. iron.

The solution of zinc-chloride shall then be run out, and creosote oil immediately admitted to the cylinder, adequate pressure applied, and oil injected into the ties to the average amount of 3 lbs. of oil per cubic foot of timber. The oil shall be heated to a temperature of not less than 140 degrees before admission to the cylinder. Cylinders must be provided with sufficient steam coils to fully maintain the temperature during injection, and steam shall be maintained in the coils also during injection of the zinc-chloride and during vacuum. The creosote oil shall comply with the standard specifications therefor, as determined by standard method of analysis. The amount of oil absorbed shall be determined by calculation based upon gage readings taken before the introduction of the oil into the cylinder, and after forcing back the oil after treatment.

Daily reports of injections shall be made and at least once a week, an account of stock shall be taken, and balance established, to check the reported amounts used.

In making all measurements the oil should be at a constant temperature or they should be reduced to a constant temperature by a proper reduction factor.

The oil shall be analyzed when received at the works; the samples being taken in the manner prescribed by the specifications for oil. At least once during each week samples of oil shall be taken from the cylinders during treatment and analyzed to determine if the water in the oil exceeds the limits of the specifications. If so, a correspondingly greater amount shall be injected. If the amount of water exceeds six (6) per cent., steps shall be taken before it is used to remove the water, so as to bring the oil within the limits of the specifications.

*DETERMINATION OF ZINC IN TREATED TIMBERS.

(Note.—It is suggested that this method be applied by a chemist.)

(1) *Taking Samples.*—The tools necessary for taking samples are a cross-cut saw and a one-inch auger. These should be wiped perfectly clean each time before taking a sample, in order to avoid contaminating the samples.

(2) The timbers from which samples are to be taken for analysis should be selected before the charge is loaded, and carefully weighed individually. They should be average size and comparatively free from knots. After treatment they should be weighed and then piled until the dripping has stopped, when the samples may be taken.

(3) For ordinary determinations, timbers such as ties should be sawed at two points, viz., two feet from the end and at the center of the tie. These sections should be designated Section No. 1 and Section No. 2, respectively. In special cases where it may be necessary to cut a tie into several sections, the exact distance from the end to each section should be given.

(4) When a large number of ties are to be analyzed, it will be sufficient to cut but one section two feet from the end, thereby saving the six-foot piece for a narrow-gage tie.

(5) After the sections have been cut, three samples should be taken from each section, as follows: No. 1, one-half inch from outside; No. 3, at the center of the section; No. 2, half-way between No. 1 and No. 3. The samples are taken by boring a hole 2 in. deep with a one-inch bit, saving all the borings. Each sample should be properly labeled, as Tie No. —, Section No. —, Sample No. —, and a list made showing the location, date, number of run, kind of treatment and weight of each tie before and after treatment.

(6) *Method of Determining Zinc-Chloride in Samples.*—Three grammes of dry borings should be weighed into a 250 cc. flask and three

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*Adopted, Vol. 9, 1908, pp. 712-714, 768; Vol. 11, Part 2, 1911, pp. 746, 747, 860.

cc. concentrated sulphuric acid added. The flask should be gently heated on a sand bath or hot plate until the wood becomes thoroughly charred. A few drops of concentrated nitric acid should then be added. When the brown fumes have disappeared, a few more drops should be added, and the addition continued, a few drops at a time (toward the last the amount should be increased), until the organic matter is all destroyed. When this point is reached, the liquid will remain colorless on further heating. The flask should then be allowed to cool and diluted with 100 cc. of water (the water should be added carefully at first). As a rule, the residue in the flask will be completely dissolved, but if there should be a slight sediment, it may be disregarded. Ammonium hydroxide should be added until distinctly alkaline, and allowed to cool. If there is a precipitate of iron hydroxide, or if there has been any undissolved sediment in the flask, it should be filtered; if not, it should be poured into a 400 cc. beaker and 5 cc. ammonium sulphide added and allowed to stand over night. It should then be filtered into an 11 cm. filter paper, washing thoroughly with water containing ammonium sulphide, and dried. It should then be incinerated in a porcelain crucible and roasted until the zinc-chloride is converted to zinc oxide. The weight should be divided by three and the result multiplied by 1.674, which will give the number of grammes of zinc-chloride contained in one gramme of the wood examined, or the number of pounds per pound. To convert this result into pounds of zinc-chloride per cubic foot of wood, multiply by the weight in pounds of one cubic foot of the wood.

The fractions remaining after extracting the phenols from the distillate should be placed in a conical vessel, such as a graduate, and surrounded by a freezing mixture of ice and salt, and allowed to remain until completely frozen. The naphthalenes so frozen should be chopped up with a knife or mashed and placed in a small brass cylinder about 1½ in. in diameter by 4 in. long, open at both ends, but fitted with small brass plates or plugs. Before putting the naphthalene in, place several thicknesses of blotting paper, cut to fit the cylinder on the bottom plate, and before putting in the top plate introduce similar blotting pads. Place several sheets of blotting pads on the plate of a copy press, put the cylinder so charged in the press and apply pressure to the top plate or plug, leaving it for about one hour. A plug of clean white naphthalene is the result, and may be taken out and weighed.

COMMITTEE XVIII.

ELECTRICITY.

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*DEFINITIONS.

THIRD-RAIL CLEARANCE LINES.—The distance between the gage of the running rail and the gage of the third rail.

EQUIPMENT CLEARANCE LINES.—Lines beyond which no part of the equipment shall project. Allowance must be made by equipment manufacturer for new equipment for wear on journals and brasses, on axle collars, on rail, on wheels, compression of springs, sagging of center of car, constructional variations, end play, broken springs, etc.

THIRD-RAIL GAGE.—Distance, measured parallel to plane of top of both running rails, between gage line of running rail and center line of third rail.

ELECTRICAL SUPERVISOR.—An officer on the division staff qualified to supervise the maintenance of the electrical transmission and working conductors outside of the power stations and sub-stations.

BONDERS.—Employes qualified to maintain rail and other bonds and their appurtenances.

TRACTION LINEMEN.—Employes qualified to maintain wires and cables and their appurtenances for all railroad voltages.

PATROLMEN.—Employes qualified to inspect and make minor repairs to track and third-rail structures, cables and wires, and to use hand signals for the protection of trains.

BOND.—A metallic means for connecting two rails to permit of passage of electric current.

CABLE.—A rope composed of wires for the transmission of electricity.

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* Adopted, Vol. 12, Part 1, 1911.

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1. The title of the volume will be *"Manual of the American Railway Engineering Association,"* edited under the supervision of the Board of Direction.

2. The Board of Direction shall have authority to exclude from the Manual any matter which, in its judgment, it shall consider as not desirable to publish, or as not being in proper shape, or as not having received proper study and consideration.

3. The adoption by the Association and subsequent publication of any matter in the Manual shall be considered in the nature of principles of good practice, and shall not be binding on the members.

4. The Manual will only include resolutions, conclusions, recommendations, plans, etc., relating to definitions, specifications or principles of practice of such questions connected with railway engineering and maintenance of way work which have been made the subject of a special study by a Standing or Special Committee and embodied in a committee report, published not less than thirty days prior to the annual convention, and submitted by the Committee to the annual convention, and which, after due consideration and discussion, shall have been voted on and formally adopted by the Association; subjects which, in the opinion of the Board of Direction, should be reviewed by the American Railway Association, may be referred to that Association before being published in the Manual

5. All resolutions, conclusions, recommendations, specifications, standards, etc., in order to be included in the Manual, must be in concise and proper final shape for publication, as the Manual will consist only of a summary record of the definitions, principles of practice, specifications and standards, acted upon by the Association, with a brief reference to the published Proceedings of the Association for the context of the Committee report and subsequent discussion and the final action of the Association.

6. Any matter published in the Manual may be amended, revised, extended or withdrawn by vote at any subsequent annual convention, provided such changes are proposed in time for publication not less than thirty days prior to the annual convention, and in the following manner: (a) Upon recommendation of the Committee in charge of the subject; (b) upon recommendation of the Board of Direction; (c) upon request of five members, subject to the action of the Board of Direction under Rule 2.

7. The Manual will be revised annually and kept up to date by publishing a new edition or a supplemental pamphlet as promptly as possible after each annual convention.

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